MONTHLY BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(ENGLISH EDITION)

PUBLISHING and EDITORIAL OFFICES : 74, RUE DU PROGRÈS, BRUSSELS.

Yearly prepaid subscription { **Belgium . . . . . 70 Belgas** / **Other countries . . 75 Belgas** } including postage

Price of this single copy : 8 Belgas (not including postage).

(1 Belga = 5 Belgian francs.)

Subscriptions and orders for single copies (January 1931 and later editions) to be addressed to the General Secretary, International Railway Congress Association, 74, rue du Progrès, Brussels (Belgium).

Orders for copies previous to January 1931 should be addressed to Messrs. Weissenbruch & Co. Ltd., Printers, 49, rue du Poinçon, Brussels.

Advertisements : All communications should be addressed to the Association, **74, rue du Progrès, Brussels.**

CONTENTS OF THE NUMBER FOR JULY 1935.

CONTENTS.	Page.
I. **Competition by roads, waterways and airways** (France and French Indo-China)	765
The world crisis and railways : Effects of the crisis on railway working and **measures taken to lessen these effects, etc. :**	
II. Second report, covering main line railways, except those affiliated to the International Railway Union (U. I. C.), by Mr. ASHTON DAVIES . . .	771
III. Second report, covering countries of Southern Europe and their Colonies, by E. LAVALLE and E. MELLINI	791
IV. A contribution to the **comparative study of the different types of electric transmission used on diesel-electric railcars,** by E. HENNIG	797
V. **Note on train speeds,** by LIONEL WIENER. — Part II (*continued*). — **Train speeds and services in the different countries : IX. Switzerland** (*to be continued*)	817
VI. **Is the steam locomotive out of date ?** by H. NORDMANN	857
VII. RECENT DEVELOPMENTS IN RAILWAY PRACTICE :	
Welded coal wagons for the London and North Eastern Railway Company	879

CONTENTS (*continued*). Page.

VIII. New books and publications :

Die **Einheitslokomotiven der Deutschen Reichsbahn im Bild** (Reichsbahn standard locomotives illustrated), 4th edition, by Hermann Maey . . . 881

American Railway Signaling Principles and Practices. — Chapter XV : **Automatic block systems**, by the American Association of Railways, Signal Section 881

Neuzeitliche Organisation im Eisenbahngüterverkehr. Abrechnung — Kontrolle — Statistik (*Up-to-date organisation in railway goods traffic. Accountancy — Control — Statistics*), by P. Riedel 882

El Problema de las detasas. Las reclamaciones por excesos de portes y las juntas de detasas (*The problem of rate reductions. Claims against high rates, and the Rates Committees*), by E. d'Ocon Cortes 883

Les Grands Réseaux de Chemins de fer français, année 1934 (*The French Main Line Railways, 1934*), by R. Godfernaux 884

Kommentar zur Eisenbahnbau und Betriebsordnung vom 17. Juli 1928 (*Commentary on the Rules for the construction and operation of railways*). — 4th edition, revised and enlarged, by F. Besser 885

IX. Monthly Bibliography of Railways 87

LIBRARY

OF THE

Permanent Commission of the International Railway Congress Association.

READING ROOM : 74, rue du Progrès, Brussels.

Works in connection with railway matters which are presented to the Permanent Commission are mentioned in the « Bulletin ». They are filed and placed in the library. If the Executive Committee deems it advisable, they are made the subject of a special notice. Books and publications placed in the reading room may be consulted by any person in possession of an introduction delivered by a member of the Association. Books, etc., may not be taken away except by special permission of the Executive Committee.

The Permanent Commission of the Association is not responsible for the opinions expressed in the articles published in the Bulletin.

All original articles and papers published in the BULLETIN are copyright, except with the consent of the Authors and the Committee.

Editions in **French** and in **German** are also published.

656.06
INT
v.17 cop.2

Vol. XVII. — No. 7. July 1935.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[656]

Competition by roads, waterways and airways.

(*Continuation*) (1).

France, French Indo-China.

FRANCE

This note is another in the series already communicated to us by the Management Committee of the French Main-Line Companies. It refers to the fourth quarter of 1934.

I. — Road competition.

A. — Statistics relating to such competition. — Passengers.

Length in kilom. (in miles) of road motor services regularly operated in France on the 31st December 1934 (approximate figures).

Description of services.	*Alsace-Lorraine.*	*Est.*	*State.*	*Nord.*	*Paris-Orléans and Midi.*	*P. L. M.*
1. *Permanent services worked :*						
a) By the railways	None.	None.	None.	None.	None.	None.
b) By concession-holders on behalf of the railways . .	150 *(93.2)*	475 *(295.1)*	190 *(119.1)*	500 *(311)*	300 *(186.4)*	1 280 *(795.4)*
c) By other public undertakings	7 300 *(4 536)*	12 150 *(7 767)*	29 550 *(18 642)*	16 150 *(10 035)*	49 600 *(30 821)*	27 250 *(16 933)*
2. *Temporary services worked :*						
a) By the railways	None.	None.	None.	None.	None.	None.
b) By concession-holders on behalf of the railways . .	1 282 *(795.4)*	23 *(14.3)*	None.	93 *(57.7)*	None.	None.

(1) Cf. *Bulletin of the Railway Congress Association*, June 1934 to June 1935.

1058997

B. — Statistics on competition in goods transport.

Number of lorries in circulation in France on the 31st December 1934 :

No new information has been received in this connection to modify the figures already published for 1933.

C. — Measures taken by the Main-Line Companies to fight motor competition.

1. Technical measures.

a) *Organisation of road motor services.*

No new services could be started in view of the regulations imposed by the decree of the 19th April 1934, on the co-ordination of railway and road transport, which stipulates, in clause 5, that until the ministerial decrees sanctioning the proposals of the Co-ordination Committee are published, no new public transport service can be introduced.

b) *Introduction of railcars.*

The *Alsace-Lorraine* Railways have put rail motor coaches into service over the following routes :

On the 7th October 1934 : Strasbourg—Sarreguemines; Sarrebourg—Sarreguemines; Hargarten-Falck—Valklingen.

Metz—Hargarten-Falk; Metz—Sarrebourg; Metz—Dilligen; Metz—Conflans; Metz—Thionville; Thionville—Apach.

On the 2nd November 1934 : Metz—Bettelainville; Metz—Conflans; Metz—Thionville; Thionville—Luxembourg; Thionville—Audun-le-Roman; Thionville—Apach; Luxembourg—Kleibettingen (Arlon).

On the 3rd December 1934 : Mulhouse—Kruth; Mulhouse—Lautenbach; Mulhouse—Colmar; Mulhouse—Neuenbourg; Mulhouse—Basle.

The total daily mileage worked by the railcars, which was 2 331 km. (1 454 miles) in September 1934, had risen to 4 029 km. (2 453.6 miles) by December.

These railcars partly replace existing trains, but at faster timings; however, they also work new services.

The *State* Railways have put railcars into service or increased the existing railcar services on the following lines :

Paris—Havre; Paris—Caen; Chartres—Rouen; Paris—Dieppe; Le Mans—Angers and La Possonnière—Chalet; Morlaix—Roscoff; Paris—Bordeaux; Angoulême—Saintes and Pons—Royan; Alençon—Condé-sur-Huisne and La Hutte-Colombiers—Laigle; Trouville—Cabourg; Le Mans—Paris and Thouars—Paris.

These railcar services have made it possible to introduce additional connections, in particular between Paris and various towns on the system, as well as to shorten the journey time.

The *Nord* Railway has introduced additional services on the lines ending at Compiègne, and has thus increased the efficiency of its railcar services.

The *Paris-Orléans — Midi* Railways started a railcar service between Rodez—Carmaux—Albi and Toulouse on the 1st December 1934.

These services, which previously were worked by trains, were improved and two additional services introduced in each direction between Carmaux, Albi and Toulouse.

The *Paris-Lyons-Mediterranean* has introduced or intensified its railbus services on the Paris—Lyons line (fast service), the Lyons—Grenoble line, and in the suburbs of Nice.

c) *Increase in the speed of trains.*

The *Nord*, by agreement with the Belgian National Railways Company, has speeded up train No. 192 (Brussels—Paris), and thereby reduced the journey

time between Brussels and Paris from 5 hours 39 minutes to 5 hours 30 minutes.

The *Paris-Lyons-Mediterranean* has accelerated 23 of its trains, particularly in the services connecting Paris, Lyons, Marseilles and Mentone.

d) *Introduction of through services.*

On the *Alsace-Lorraine*, the development of the railcar services has made it possible to introduce some twenty new connections.

On the *Nord*, new light trains running at higher speeds have been introduced during the slack hours of the day on various suburban lines.

A new liaison has been introduced between Mouscron and Tourcoing, to give a connection between the Belgian train which ends its journey at Mouscron, and express train No. 318 which starts from Tourcoing.

New connections have been introduced, and new stops on several lines on this system.

On the *Paris-Orléans—Midi* Lines, the Bordeaux-Milan train has been retimed a little later from Bordeaux-St. Jean in order to improve the international connections through Modane.

On the *Paris-Lyons-Mediterranean*, rapide No. 25 from Paris has been made to connect at Avignon with express trains to Nîmes, Sète, Narbonne and Perpignan.

The speeding up of trains No. 609 and 610 has markedly improved the service between Paris and Rome.

e) *Organisation of parcels collecting services.*

As a result of the steps already taken on the *Alsace-Lorraine*, to increase the number of deliveries between the large transhipment centres, the use of passenger and mail trains for the transport of slow goods parcels has been made general over all the lines on this system.

f) *Container traffic.*

The railways are continually extending the use of containers in the way described in the previous notes. To make it easier to handle large containers the *Nord* has put into service, at Lille, a mobile crane, as well as one at La Chapelle, both of which are put at the service of the public without charge.

g) *Door to door services.*

Development of cartage and delivery services.

The *Est* has organised new special door-to-door delivery services at the request of the multiple-branch stores. These services are becoming general in the case of grocery consignments and empty packings in complete wagon loads.

On the *State*, four new places have been served by cartage and delivery service during the fourth quarter of 1934.

On the « Etoile de Mortagne » lines, door-to-door collection and delivery is still carried out by the lorries working the goods traffic.

On the *Paris-Orléans—Midi* the cartage and redispatching services have been extended to 184 new places.

Door-to-door collection and delivery is still covered by the F.A.D. service lorries between Orleans and Tours. This service has developed in a satisfactory way during the fourth quarter of 1934.

h) *Other measures.*

The railways have organised 93 parcels collecting offices at various business houses, in Paris, where ordinary post parcels for the interior of the country are accepted. The parcels are taken to the rail-heads concerned under the same conditions as from the ordinary parcels collecting offices.

The *Nord* has extended the arrange-

ments previously made to favour door-to-door services carried out through the intermediary of grouping agents (reduced rates, improvement of the services, extension of station hours, covered sidings at the disposal of groupers for warehousing and sorting out their goods).

The *Paris-Orléans—Midi* have opened four new parcels offices in the provinces (three at Limoges, and one at Blanc) at which consignors can hand in post parcels, or packages of a weight not exceeding 50 kgr. (110 lb.).

2. Commercial measures.

a) *Introduction of special tariffs.*

I. — PASSENGER RATES.

Special rate V 6/106—Heading II. — As from the 15th December 1934, tickets for the Côte d'Azur and the Côte Basque available for 33 days are issued at a reduction of 20 to 30 % (Period from the 15th December to 30th April .

II. — GOODS RATES.

The Main-Line Companies have found it necessary to introduce a good many tariff measures, either applying to internal or general traffic, such as fixed rates and contract rates, which affect in particular grouped goods transport over many lines, as well as various special classes of goods, such as semolina, sugar, empty bottles, plant and implements for fairs, etc.

3. Negociations between the main-line companies and public passenger motor transport services.

Representatives of the Main-Line Companies have continued their negociations with Road Passenger Transport Firms during the last quarter of 1934, and these have led to agreements in the case of the départments of Deux-Sèvres, Haut-Rhin, Bas-Rhin, Aude, Hérault, Pyrénées-Orientales, Lot, Gironde, Charente, Dordogne, Lot-et-Garonne, Gers and Landes, which brings the number of départements in which passenger co-ordination agreements have been signed up to nearly twenty-five.

These arrangements cannot, however, come into force until they have been re-examined in the light of the new decree of the 25th February 1935, in pursuance of which Departmental Technical Committees are instituted for the examination and application of such agreements, which will greatly facilitate the work of these Committees.

D. — Modifications in legislation likely to affect the relations between the railway and road services.

1. *Co-ordination of railway and road.*

Co-ordination Committee.

After the resignation of the members representing road transporters who had not a contract with the State, départements or communes, a *ministerial decree of the 6th December 1934* provided for their replacement, after further consultation with the professional organisations concerned.

2. *Fiscal legislation.*

By virtue of clause 3 of the *financial law of the 25th December 1934*, published in the *Official Journal* of the 25th December 1934, road vehicles with internal-combustion engines using producer gas or compressed gas are no longer liable to the operating tax as from the 1st January 1935.

3. *Legislation on working conditions.*

The *decree of the 2nd October 1934* should be noted, as it modifies the decree of the 15th August 1930 on the application of the law on the eight-hour day for transport and removal firms.

II. — Competition from water transport services.

A. — Statistics relating to such competition.

General table showing the traffic for the 4th quarter of 1934, and comparing it with the tonnage for the previous year.

Tonnage loaded during the 4th quarter. Metric tons.		In comparison with 1933.	Tonnage loaded since the beginning of the year. Metric tons.		In comparison with 1933.
1934	1933	Increase %.	1934	1933	Increase %.
13 379 608	11 276 789	18.6	51 008 806	50 030 328	1.9

B. — Steps taken by the railways to meet water transport competition.

1. *Rates.*

During the fourth quarter of 1934, the Main-Line Companies were obliged to grant various reduced rates, fixed and contract, in favour of certain goods, such as exotic woods, fuel, minerals, plaster, clinker, metallurgical products, soda, grouped goods and oranges in transit, etc.

These rates were the subject of an examination by the regional Co-ordination Committees before representatives of water and railway interests as soon as such Committees had been set up.

2. *Agreements made between the railways and navigation.*

The agreement made between the Paris-Lyons-Mediterranean and the Rhône Navigation interests, on the 26th July 1934, was examined by the 6th Regional Co-ordination Commission of railway and water transport.

Moreover, an agreement was made in the case of canals in the Southern France, on the 10th December 1934, between the Paris-Orléans—Midi and the River Transporters Association in Southern France. This will be submitted to examination by the 7th Regional Commission.

C. — Modifications in legislation likely to affect the relations between the railway and water transport interests.

Since the decree of the 28th October 1934 and the ministerial decree of the 29th October mentioned in the previous note about the third quarter, mention must be made of :

1. *Two ministerial decrees of the 7th November 1934 :*

— one nominating the experts to represent the Main-Line Companies and the professional water transport organisations on the Central Committee for the Co-ordination of railway and water transport,

— and the other, regulating the procedure to be followed when considering requests for the registration of boats.

2. *the ministerial decree of the 6th December 1934,* relating to the composition of the Regional Commissions set up in connection with the Central Committee for the Co-ordination of railway and water transport.

III. — Air competition.

A. — Statistics relating to the traffic of the main French airways.

1. Passengers carried during the fourth quarter of 1934 : 10 640.

2. Parcels, papers, excess luggage, carried during the fourth quarter of 1934 : 301 077 kgr. (296 Engl. tons).

3. Mails : 56 726 kgr. (55.8 Engl. tons).

B. — Steps taken by the railways to meet this competition.

Closer timing of the fast trains.

The *Nord* has accelerated the « Oiseau Bleu » express train, which now takes 3 hours 3 minutes (instead of 3 hours 15 minutes) to cover the distance between Brussels and Paris, i.e. the overall speed is 102 km. (63.4 miles) an hour.

C. — Efforts to arrive at collaboration.

(Combined air and railway transport).

None.

D. — Modifications in legislation likely to affect the relations between the railways and air transport firms.

None.

FRENCH INDO-CHINA

The *Compagnie Française des Chemins de fer de l'Indochine et du Yunnan* has sent us the following information about the first quarter of 1935 :

I. — Steps taken by the Company :

a) *In the case of passenger traffic.* — Special provisional tariffs at reduced rates, applicable to 3rd and 4th-class passengers on the occasion of the Têt holiday :

Special temporary tariff at fixed rates applicable to passengers making certain journeys in the first rating zone;

Reduction of the special temporary rates applicable to 4th-class passengers in the first zone.

b) *In the case of goods traffic.* — Putting into force of various tariffs at fixed rates for the transport from Hanoi to Hai-Fong, and vice-versa, of all kinds of goods, the price corresponding to minimum weights per consignment in the case of small consignments and per complete wagon load in the case of bulk consignments. The rates for the consignment of iron, steel and cement from Hai-Fong or a branch from Hai-Fong to Hanoi is based on a minimum of 10 and 20 tons.

The rates under consideration grant reductions in the form of a 10 % rebate if the tonnage sent by the same consignor reaches a given total during the three months.

II. — Steps taken by the Public Authorities.

Extension, until the 14th April 1935, of the period to elapse until the regulations on the operation of motor passenger or goods transport services come into force.

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION.

INQUIRY INTO QUESTIONS OF IMMEDIATE INTEREST.

(Decision taken by the Permanent Commission at its Meeting held on July 29th, 1933.)

QUESTION II.

" The World Crisis and Railways "

and the effects of the crisis on railway working; measures taken to lessen the effects of the crisis; competition or collaboration between railway and road transport; a forecast of the future; new ideas as to passenger transport, such as light quick trains between large towns and between large and small towns, running at regular intervals ».

SECOND REPORT

(Main-line railways of all countries except those affiliated to the International Railway Union).

by Mr. ASHTON DAVIES, O.B.E.,
Chief Commercial Manager, London Midland & Scottish Railway.

I. — Introduction.

My first report on the above subject was produced in April 1933, and this second report is issued in order to bring the former up-to-date by the addition of material concerning events that have occurred subsequently, where these show progress or variation in the situation as portrayed in the main report.

Broadly, I have followed the sequence of the main report but, of the companies reported upon, a slight variation will be observed.

Wherever ascertainable, statistical information has been brought up-to-date.

As on the previous occasion, some of the railways have not sent in any information for incorporation in my report and whilst every precaution has been taken to ensure accuracy of fact and figure, many of these are not at first hand. Further, in some instances the information supplied was not strictly admissible as relevant to the remit.

Acknowledgments are due to the Railway Research Service Bureau in London, from whom I have received much useful assistance and information.

II. — Reports.

The reports on the various railways follow in order thus :

Country.	Name of Railway.
1. The United States of America . .	
2. Argentina	Buenos Aires Great Southern.
	Buenos Aires Pacific.
	Buenos Aires Western.
	Central Argentine.
	Entre Rios.
3. Brazil	Great Western of Brazil.
4. Uruguay	Central Uruguay Ry. of Montevideo.
5. Ireland	Great Northern.
	Great Southern.
6. British Africa	South African Railways and Harbours.
	Kenya & Uganda.
	Nigerian.
7. Egypt	Egyptian State.
8. Sudan	Sudan Government Railways.
9. Ceylon	Ceylon Government.
10. India	
11. East Indies	Netherlands East India State Railway.
12. New Zealand	New Zealand Government.

From this it will be seen that no further comment appears with respect to Canada or the Federated Malay States, but that the Sudan Government Railways and the Netherlands East India State Railway are introduced.

* * *

The United States of America.

The year 1934 was the third in which the American Railways as a whole failed to earn their fixed charges. The depression continues to be the main cause of their position, added to which are high operating expenses, chiefly due to high wages, advances in prices of material and competition by road, water and air. In 1933, there was a further decrease in the total revenue due to a heavy fall in the passenger earnings. In 1934, which showed an improvement over 1933, both passenger and freight business contributed to the gross increase. The net revenue position in 1933 showed an improvement over 1932 due to reduced operating expenses, but in 1934 these again increased and the improvement in revenue was more than absorded by increased labour and material costs and the net income available for fixed charges fell short of meeting those fixed charges by about 32 000 000 dollars, compared with a deficit of 6 000 000 dollars in 1933 and 139 000 000 in 1932.

The following are the latest figures available for Class 1 Railroads (over 95 % of the total United States mileage).

CLASS 1 RAILROADS.

Year.	Operating revenue.	Operating expenses.	Net railway operating income.	% of expenses to revenue.
	Dollars.	*Dollars.*	*Dollars.*	
1929	6 279 millions.	4 506 millions.	1 773 millions.	71.7 %
1930	5 281 —	3 931 —	1 350 —	74.4 %
1931	4 188 —	3 223 —	965 —	76.9 %
1932	3 127 —	2 404 —	723 —	76.8 %
1933	3 096 —	2 250 —	846 —	72.7 %
1934	3 271 —	2 442 —	829 —	74.6 %

Year.	Gross freight receipt.	Gross passenger receipts.
	Dollars.	*Dollars.*
1929	4 826 millions.	874 millions.
1930	4 083 —	729 —
1931	3 255 —	551 —
1932	2 451 —	377 —
1933	2 493 —	329 —
1934	2 633 —	346 —

Year.	Less than carload originating tonnage.	Average ton-miles daily per freight car in service.
1929	36 millions.	547 ton-miles.
1930	29 —	469 —
1931	22 —	383 —
1932	15 —	300 —
1933	14 —	332 —
1934	*	378 —

Year.	Passengers carried (total).	Passengers carried (excluding suburban and season tickets).
1929	780 millions.	323 millions.
1930	704 —	265 —
1931	596 —	210 —
1932	479 —	163 —
1933	433 —	160 —
1934	*	*

Year.	Originating freight tonnage.	Average tonnage per freight train.
1929	1 339 millions.	804 tons.
1930	1 153 —	784 —
1931	894 —	733 —
1932	646 —	663 —
1933	699 —	699 —
1934	*	706 —

* 1934 figures not yet available.

AVERAGE NUMBER OF EMPLOYEES.	
Year.	Number.
1929	1 660 850
1930	1 487 839
1931	1 258 719
1932	1 031 703
1933	970 893
1934	1 009 000

Operating expenses.

In 1932, a deduction of 10 % from the standard rates of pay was agreed, to apply until 30th June, 1934. As from 1st July, 1934, 2 1/2 % was restored, which had the effect of increasing the wages bill for the second half of the year by approximately $ 20 000 000. During 1935 further restoration was effected, first by another 2 1/2 % on 1st January and the remaining 5 % on 1st April.

To this increased cost of labour was added a 4 % assessment as contribution towards a compulsory pension system. In practice, pending appeal to the U.S. Supreme Court, no action was taken. In May 1935, the U.S. Supreme Court declared this Act of Congress unconstitutional.

In addition to these increased staff costs, the companies had to pay considerably more than in the previous year for their material. On an average the main increases, 1934 over 1933, were : coal at the mine 17 %, fuel oil 15 %, sleepers 28 %, timber 32 %, iron and steel 9 %. These increases resulted from the policy pursued under the National Recovery Act, whereby hours, wages, production, price and conditions of sale were controlled.

Faced by heavier material and wages costs, the railroads have applied to the Interstate Commerce Commission for increases in freight rates. Whether, if these increases are applied, the traffic available at the new rates will result in

additional revenue being secured to offset the advance in costs is a matter which the future alone can show.

Association of American Railroads.

The Association of American Railroads was set up in 1934 with the object of meeting the need for a forceful independent organisation to act in the capacity of a general staff for the railroads as a whole.

This new organisation was necessary to co-ordinate the work of the Association of Railway Executives, the American Railway Association and several similar bodies. Study has been made of several railway problems such as the wagon pooling, the pooling and co-ordinating of the handling of merchandise and express traffic and proposed transport legislation. No indication at the moment has been given of the adoption of new policies, though as part of the functions of the Association, a Planning and Research Department is being set up.

Improvements in service.

The principal developments in passenger service during 1934, which probably have had a stimulating effect on traffic are the provision of additional services by means of streamlined trains, air conditioning of passenger coaches and increased speed.

Several long-distance services are covered by streamlined diesel-engined trains which on test attained speeds averaging over 70 miles per hour, and at least one steam record was created.

The advantages claimed for the diesel streamlined train are high speed, comfortable travel, comparatively low construction costs and economical maintenance and operation.

These specialised services appear to be well patronised, but in addition there has been a speeding up of ordinary passenger services, and many timings have been improved.

At the commencement of the year there were about 648 air-conditioned passenger carriages in service, and 1934 saw considerable advance, the number being increased by some 1 878 carriages, including 1 161 Pullman cars, and further progress is to be made in 1935.

Other inducements offered to passengers were more liberal luggage allowances and improved Pullman services.

Coupled with the foregoing, certain fare reductions were made in the West, and the combined result of the efforts of the railway companies has been to arrest the decline in passenger business, which has been persistent for some years.

Attention is directed also to the improvement of freight services, in speeding up transits, shortening journey time, improving connections and extending next-day deliveries. Collection and delivery too, was further developed with good results, while certain rate reductions practised by some companies locally on their own systems led to increased business.

The up-to-date position of other features mentioned in the main report may be briefly referred to :

Federal Co-ordinator of Transportation.

Many reports have been issued by the Co-ordinator, among which may be cited those on the railway situation in general, the regulation of motor and water carriers, the pooling of wagons, and staff and labour problems. It would appear that these reports are receiving the careful study and consideration of the railway companies but that none of them have, as yet, been adopted.

Legislation.

By the Emergency Railroad Transportation Act of 1933 it was hoped that the Co-ordinator would be enabled to improve the position of the railroads, but restrictions on the reduction of employment embodied in this Act prevented certain economies which could otherwise have been effected. In place of the present competition, it is likely that

during 1935 progress will be made in legislation towards a scheme of regulation intended to co-ordinate all forms of transport, though an indication is given that the Government do not contemplate acquiring the railways.

Small-capacity wagons.

It does not appear that advance has been made in the provision of small capacity wagons; actually very few have been built.

Passenger fares.

The evidence as to the advisability or otherwise of reducing passenger fares in order to attract traffic, shows a divergence of opinion. The problem is different in the Eastern States from what it is in the West ans South, and the various traffics to be catered for make the application of a universal basic rate difficult. Whilst reductions to recover business lost to road may be desirable in some directions, the view appears to be held that it is extremely doubtful whether the receipts from the additional business accruing as a result would offset the loss in revenue caused by the reduction. The whole question is still under investigation and consideration.

Lines abandoned.

It is significant of the period through which the United States railroads are passing that the mileage of lines abandoned in 1934 reached an unprecedented figure. A comparison of lines constructed and abandoned during recent years is shown by the following table :

Year.	Miles of line.	
	New completed.	Abandoned.
1929	666	475
1930	513	694
1931	748	795
1932	163	1 452
1933	24	1 876
1934	76	1 995

Argentina.

Buenos Aires Great Southern Railway.

Year.	Gross receipts.	Working expenses.	Net receipts.
	£	£	£
1929	13 066 788	8 754 445	4 312 343
1930	12 214 561	8 782 900	3 431 661
1931	11 348 749	7 958 638	3 390 111
1932	10 561 447	7 420 493	3 140 954
1933	10 560 668	7 417 265	3 143 403
1934	10 516 260	7 347 472	3 168 787

Passenger receipts.

Year.	General.	Suburban.	Good receipts.
	£	£	£
1929	1 918 000	1 225 339	6 799 000
1930	1 890 000	1 236 857	6 144 000
1931	1 824 000	1 238 496	5 513 000
1932	1 489 000	1 186 039	5 357 000
1933	1 462 000	1 146 460	5 386 993
1934	1 548 482	1 101 155	5 327 835

The measures previously reported have been continued with beneficial results. During 1934 there has been a slight upward tendency in some traffics and an increase in net receipts. Grain prices have improved somewhat which has had the effect of alleviating in some degree the depression.

Expenditure has been most carefully watched, particularly as to renewals. The provision of motor trollies for permanent way gangs has been fully justified. A scheme has been introduced for practical instruction in their duties to be given to permanent way staff and increased efficiency has resulted.

Legislation for the co-ordination of country road transport is under consideration. To combat road competition the methods indicated in the main report are being pursued and certain reduced rates for milk have enabled a reasonable tonnage to be recovered.

Buenos Aires and Pacific Railway.

Year.	Gross receipts.	Working expenses.	Net receipts.
	£	£	£
1929	9 134 333	6 436 223	2 698 110
1930	7 854 906	5 715 966	2 138 940
1931	7 067 293	5 557 376	1 509 917
1932	6 473 312	5 047 515	1 425 798
1933	5 827 691	4 835 125	992 566
1934	5 843 973	4 641 886	1 202 087

Year.	Passenger receipts.	Goods receipts.
	£	£
1929	1 425 944	6 953 473
1930	1 303 094	5 706 716
1931	1 127 743	5 128 838
1932	911 015	4 914 114
1933	866 547	3 889 628
1934	734 922	4 125 449

In common with other Argentina companies the Buenos Aires and Pacific Railway has experienced financial difficulty on account of currency restrictions.

The practice of economy has been continued with effect, as is seen from the above figures which show progressive reductions in working expenses, though the saving would have been greater had the company been able to reduce staff and wages proportionately to business.

Apart from the trade depression which affected long and short-distance passenger traffic, road competition was in the main responsible for a decrease in suburban traffic. International traffic was adversely affected by air competition and the closing of the Transandine Railway owing to floods.

A cheapening in the price of wine brought increased freight receipts, to which additional carryings of wheat also contributed.

Buenos Aires Western Railway.

Year.	Gross receipts.	Working expenses.	Net receipts.
	£	£	£
1929	5 275 311	3 457 808	1 817 503
1930	4 381 349	3 340 693	1 040 656
1931	3 822 119	3 042 465	779 654
1932	3 729 929	2 904 596	825 333
1933	3 546 426	2 893 942	657 484
1934	3 612 117	2 838 247	778 870

Year.	Passenger receipts.	Goods receipts.
	£	£
1929	1 164 730	2 603 937
1930	1 124 811	1 889 369
1931	1 025 641	1 618 408
1932	877 018	1 697 163
1933	767 941	1 589 719
1934	736 105	1 708 564

The rise in the price of cereals has materially improved the prospects of the company, though the continued fall in the peso has affected the position financially.

Very keen competition by trams, buses and collective taxis was maintained, which resulted in suburban passenger receipts in 1934 being less than those for 1933 by £ 32 182. Long-distance excursions were developed, which enabled main-line passenger receipts to show a small increase.

To supply more frequent services for long-distance passengers, diesel railcars are being tested.

To meet intensified lorry competition for milk traffic, the milk rates have been revised.

The entire working of the railway was overhauled by a special committee, with substantial results in economies, and further progress is anticipated.

Tariff problems and proposals for dealing with short-distance traffic lost to road are to be subjects for special study in conjunction with the Railway Clearing House, Buenos Aires.

Central Argentine Railway.

Year.	Gross receipts.	Working expenses.	Net receipts.
	£	£	£
1929	14 251 698	9 817 897	4 433 801
1930	11 567 717	8 639 855	2 927 862
1931	11 196 658	8 181 903	3 014 755
1932	11 405 739	8 227 300	3 178 439
1933	9 749 195	7 849 021	1 900 174
1934	9 870 864	7 210 962	2 659 902

Year.	Passenger receipts.	Goods receipts.
	£	£
1929	3 416 000	9 669 000
1930	3 387 000	7 151 000
1931	3 012 000	7 106 000
1932	2 674 000	7 736 000
1933	2 383 000	6 196 000
1934	2 190 973	6 090 937

Continued attention has been paid to the economic possibilities attending the use of new materials and the introduction of new methods of construction. Whilst mechanised track laying offers no prospect of economy, the standardisation of rolling stock, components, permanent way materials, etc., is receiving special attention.

Articulated and single diesel rail cars are being put into service in a suburban area where road competition has been keenly felt during recent years. The seating capacity of each of the articulated units is 149 passengers, and each of the single units seats 75 passengers.

Entre Rios Railway.

Year.	Gross receipts.	Working expenses.	Net receipts.
	£	£	£
1929	1 543 172	986 503	556 669
1930	1 430 209	991 419	438 790
1931	1 416 122	975 818	440 304
1932	1 122 745	822 539	300 206
1933	778 921	741 977	36 944
1934	805 833	722 235	83 598

Year.	Passenger receipts.	Goods receipts.
	£	£
1929	236 546	1 105 146
1930	234 969	1 007 645
1931	209 398	1 016 838
1932	171 386	778 907
1933	138 903	445 741
1934	132 630	457 460

Rigid economy continues to be practised, with the result that working expenses in 1934 again showed a decrease.

Certain crops were affected by damage from locusts which is reflected in the receipts which also suffered owing to the continuance of keen road competition. The commercial and financial position of the district served by the railway has not improved, and difficulty continued to be experienced with currency exchange.

Reorganisation of the provincial passenger service is contemplated whereby fast day trains will be accelerated and motor coaches substituted for trains connecting the various lines in the provinces.

Brazil.

Great Western of Brazil Railway.

Year.	Gross receipts.	Rate of exchange per milreis.	Working expenses.	Net receipts.
	£	Pence.	£	£
1929	976 424	5.89	715 984	260 440
1930	701 223	5.34	588 080	113 143
1931	426 921	3.92	394 379	32 542
1932	576 820	4.83	482 041	94 779
1933	533 493	4.59	489 416	44 077

Year.	Passenger receipts.	Goods receipts and tonnage.	
		Receipts.	Tons.
	£	£	
1929	183 106	714 290	2 144 784
1930	131 513	510 045	1 919 904
1931	87 603	306 632	1 447 287
1932	119 027	418 730	1 257 425
1933	117 522	378 212	1 134 466

The decrease in gross receipts for the year 1933 compared with 1932 may be ascribed to intensified road competition, also to the fact that the sugar crop ended sooner.

Again, exchange difficulties adversely affected the financial position of the Company.

In order to combat road competition for freight traffic, goods trains were accelerated.

Uruguay.

Central Uruguay Railway of Montevideo.

Year.	Gross receipts.	Working expenses.	Net receipts.
	£	£	£
1929	1 561 058	1 123 626	437 432
1930	1 621 290	1 192 560	428 730
1931	1 191 023	887 777	303 246
1932	692 504	504 746	187 758
1933	1 125 443	766 472	358 971
1934	1 205 005	844 308	360 697

Year.	Passenger receipts.	Goods receipts.
	£	£
1929	469 124	1 209 090
1930	480 161	1 160 063
1931	340 705	785 082
1932	217 294	498 282
1933	217 153	565 269
1934	209 267	615 119

The commercial and economic depression continued unabated, and locusts and drought further contributed to retard recovery.

Economy is strictly enforced and renewal work has been kept down to the minimum compatible with safety.

Ireland.

Great Northern Railway (Ireland).

Year.	Gross receipts.	Working expenses.	Net receipts.
	£	£	£
1929	1 662 680	1 387 297	275 392
1930	1 623 822	1 436 106	187 716
1931	1 558 172	1 378 958	179 214
1932	1 389 912	1 360 954	28 958
1933	1 003 534	1 075 469	71 935 Debit.
1934	1 247 912	1 207 188	40 724

The year 1933 was the worst in the history of the Company, but 1934 resulted in a considerable recovery. Although the gross receipts did not reach the 1932 level, the net receipts were much in advance of those of that year.

The use of diesel railcars for suburban traffic is being extended.

Apart from the world depression, reflected in local conditions, and increased salaries and wages, unrestricted and uneconomic road competition has greatly depleted railway revenue.

The Motor Vehicles (Traffic and Regulation) Act (N.I.) 1926 was the first step in legislation taken in Northern Ireland to bring road operators under a measure of control, and considerable reductions have been made in the number of separate operators licensed to run regular passenger services. The licensing of goods vehicles, however, was much delayed.

The whole transport position had developed to such seriousness that at the request of the Government of Northern Ireland, Sir Felix Pole conducted an enquiry into the position and made certain recommendations as to the future of road and rail transport in Northern Ireland. These recommendations for the re-organisation of transport have been adopted by the Governement and embodied in a Bill, known as the Road and Railway Transport Bill (Northern Ireland) which was introduced in the Ulster Parliament in May, 1935. The proposal is to set up a public authority which will acquire various road undertakings whose receipts will be pooled with the purely rail receipts and disbursed on the basis of a standard year. The board will operate all public hire road transport, acquire other motor undertakings, including the passenger and freight road transport services of rail-

way companies, and co-ordinate with the railway services. With certain exceptions (principally the road transport undertaking of the Belfast Corporation) the Board will provide all public hire road transport and the duty is placed upon them of so exercising their powers as to secure in conjunction with the railways a properly guaranteed system of road, railway and other means of transport.

The passage of the Bill through Parliament and its ultimate application will be watched with interest.

Great Southern Railways (Ireland).

Year.	Gross receipts.	Working expenses.	Not receipts.
	£	£	£
1929	4 139 458	3 322 097	817 361
1930	3 961 813	3 247 855	713 958
1931	3 617 148	2 991 836	625 312
1932	3 172 460	2 767 707	404 753
1933	3 000 216	2 678 344	321 872
1934	3 857 559	3 457 544	400 015

During 1934 there was an improvement in working receipts under almost all headings though the adverse conditions mentioned in the main report still continue.

The company has benefited from the Road Transport Act of 1933, to which reference was made in the previous report. The general effect is to grant a controlled monopoly outside certain specified areas around ports, etc., of both passenger and goods services. This legislation also allows the acquirement of road transport concerns operating in the area served by the railway company's system. During 1934 a number of such undertakings was acquired and further purchases are in course of negotiation.

The company has extended its collection and delivery services, also road merchandise services operating from railhead at various railway stations and a number of direct door to door services were instituted.

The results of the policy are shown in the net receipts for 1934 which increased by £ 78 143 over 1933.

British Africa.

South African Railways and Harbours.

Year.	Gross railway receipts.	Railway working expenses.	Net railway receipts.
	£	£	£
1929	26 090 712	20 298 664	5 792 048
1930	26 130 549	20 878 539	5 252 010
1931	24 321 854	19 308 444	5 013 410
1932	22 039 659	17 604 116	4 435 543
1933	20 619 878	13 171 787	7 448 091
1934	23 707 524	14 263 267	9 444 257

Year.	Passenger receipts.	Goods receipts.	Coal receipts.
	£	£	£
1929	5 546 615	14 548 481	3 817 000
1930	5 426 670	14 567 578	3 893 000
1931	5 106 563	13 620 400	3 462 000
1932	4 685 617	12 372 135	2 959 000
1933	4 107 169	11 887 298	2 661 667
1934	4 552 651	13 985 115	2 965 476

A certain improvement has taken place in the industrial position, and the improved results shown in the net receipts are due to increased earnings and not to any further reduction in expenditure.

The increased earnings may be attributed to (1) mining development, (2) replenishment of supplies by storekeepers and merchants who had carried only very low stocks due to financial stringency, and (3) importation of new motor cars.

The policy of applying reduced fares for excursions has been pursued, but the Administration have come to the conclusion that any further reduction would produce lessened revenue with no compensating increase in business.

Through the Motor Carrier Transportation Act, 1933, a measure of control is exercised over uneconomic competition and some road motor services, previously competing with the railway, are now supplementing rail transportation as feeder services. Small omnibus competition, however, continues unabated, and animal transport by road constitutes a serious menace by keenly competing for high rated traffic.

There has been a considerable development in electrification, with savings and increased operating efficiency resulting. Further extensive projects are contemplated.

A decision has been reached to appoint a Special Committee of Research to investigate ways and means of reducing expenditure in order to lower the cost of rail transport.

The measure of trade recovery has demanded increasing passenger services, but owing to economic uncertainty, the Administration's policy has been to provide services of sufficient flexibility to meet fluctuating demands, without a definite commitment to a stabilised increased service.

In some instances, owing to increased traffic, railcars have been superseded by steam trains.

Under the title of South African Airways (South African Railways and Harbours), the Administration assumed control of air services between Durban and Capetown and Durban and Johannesburg.

Kenya and Uganda Railway and Harbours.

Year.	Gross receipts.	Working expenses.	Net receipts.	% of ordinary working expenditure (excluding depreciation) to earnings.
	£	£	£	
1929	2 448 960	1 445 070	1 003 890	59
1930	2 214 229	1 441 285	772 944	65
1931	1 903 726	1 300 805	602 921	68
1932	1 838 661	1 044 161	794 500	57
1933	2 088 162	990 054	1 098 108	47
1934	2 227 285	994 287	1 232 998	45

The above are the results of railway working of the Kenya and Uganda Railways and Harbours.

To meet the crisis, measures, as detailed in the main report, were taken and these have met with considerable success. Although the number of passenger journeys, 1934, compared with 1933, shows a decrease, and there was a slight falling off in receipts from livestock, the earnings from passengers, parcels, luggage, mails and goods have all increased. There is no change to report in method, but it is interesting to observe in 1934 that despite a decrease in freight traffic due to abnormally low export tonnages of cotton seed and maize, there was a general increase in higher rated traffics. Further, a progressive decrease has been maintained in the percentage of ordinary working expenditure to earnings.

Nigerian Railway.

Year.	Gross receipts.	Working expenses.	Net receipts.	% of working expenses to gross receipts.
	£	£	£	
1930	2 692 661	1 665 716	1 036 945	62
1931	2 154 731	1 313 209	841 522	61
1932	1 837 977	1 162 252	675 725	63
1933	1 899 050	1 111 126	788 824	58.5
1934	1 885 660	1 086 125	799 545	57.59

The measures outlined in the main report have been continued. There has been a slight decrease in gross receipts which has been offset by a reduction in costs, leaving the net position slightly better in 1934 than in 1933.

In addition to constant vigilance over expenditure, a Research Assistant to the Chief Mechanical Engineer has been appointed for the development of economies.

To combat road competition, the suburban service has been doubled, a reduced rate of twopence per ton-mile consolidated rail and port shore handling rate over first 300 miles of line north of Lagos has been introduced, and railway road lorries with trailers are used with success in one large area.

The General Manager states that the reduction of third-class passenger fares to 1/4 d. per mile has yielded a traffic increase of about 120 %.

Egypt.

Egyptian State Railways.

Year.	Gross receipts.	Working expenses.	Net receipts.	% of working expenses to gross receipts.
	£. E.	£ E.	£ E.	
1928-1929	7 163 000	4 192 000	2 971 000	59
1929-1930	7 039 000	4 076 000	2 963 000	58
1930-1931	6 038 000	4 077 000	1 961 000	68
1931-1932	4 939 000	3 624 000	1 315 000	73
1932-1933	4 707 000	3 243 000	1 465 000	69
1933-1934	5 012 000	3 304 000	1 708 000	66

It is significant that despite an increase in gross receipts shown for 1933-34, the percentage of working expenses to gross receipts has decreased during the last two financial periods. This indicates a certain recovery of business and satisfactory results from the practice of measures of economy.

Fares have been reduced to pre-war level, and special cheap day return tickets have been introduced. The effect has been that the number of passengers carried, 27 000 000 in 1929/30, increased to 34 500 000 in 1933/34, but the receipts in the same periods dropped from £ E 2 929 000 to £ E 2 063 000.

Coal represents 14 % of working expenses and special attention is paid to fuel economizing devices.

The fact that labour is cheap has a bearing upon the introduction of certain mechanical equipment, e.g., track laying, which in the circumstances, and despite the depression, would not be advantageous.

Light units have proved practical, especially the diesel type, of which there are ten which are used where locomotive feed water is unobtainable. There are 21 light steam units in operation and a further 10 are being built. The light steam units are for supplementary or replacement services on branch lines.

To meet road competition, for passenger traffic the tendency is for working arrangements to be entered into with bus companies.

Containers have been introduced for household removals thus enabling door to door transit to be given for this type of traffic.

Road competition continues to be very keen, there being little Government regulation governing insurance, hours of work, overloading, etc.

To resecure merchandise traffic from road to rail, rates have been lowered, and « universal » rates, i.e., regardless of distance, have met with a measure of success.

Sudan.

Sudan Government Railways.

Year.	RECEIPTS.			EXPENDITURE.	Net receipts.	% of expenditure to receipts.
	Passengers.	Goods.	Total.			
	£ E.	£ E.	£ E.	£ E.	£ E.	
1929	515 286	1 572 372	2 087 658	1 362 975	724 683	65
1931	232 760	1 020 858	1 253 618	994 145	259 473	79
1932	195 275	1 135 814	1 331 089	886 494	444 595	67
1933	347 319	1 075 559	1 422 878	1 037 729	385 149	73
1934	369 810	1 420 654	1 790 464	1 081 624	708 840	60

Effects of the crisis.

To the World Crisis is attributable the decreased receipts which occurred with both goods and passenger traffics in 1931 and 1932, and the loss in short-distance passenger traffic was heavy, this being susceptible to road competition. Passenger and freight services were reduced where this could be done without loss of efficiency.

Measures taken to lessen the effect of the crisis.

a) Decentralisation and re-organisation by which work was done by fewer but larger departments has, together with stricter financial control, resulted in saving in expenditure.

b) A certain number of stations have been closed.

c) Standardisation of material and

rolling stock is carried out as far as possible.

d) Reduced fares were introduced to some extent.

e) Absorption of small mechanical workshops by main locomotive shops has resulted in increased efficiency and economy. Further economy has resulted from the better diagramming of engines and rolling stock.

Light units.

No special units have been purchased.

Road competition.

Local passenger trains in certain areas have been increased with advantage. To regain freight traffic from road to rail, a policy of limited rate reduction was introduced in 1933 and exended in 1934, with some success.

By legislation, motor transport has been prohibited from operating in one district, except under licence.

General.

This summary covers the years 1933 and 1934, and the inference may be drawn that re-organisation has reduced expenditure in relation to receipts, and that these measures have materially contributed to the better position revealed in 1934 as compared with 1933, though in 1934, slightly better economic conditions undoubtedly assisted the rise in receipts.

Ceylon.

Ceylon Government Railways.

Year.	Gross receipts.	Working expenses	Net revenue.	% of working expenses to gross receipts.
	Rs.	Rs.	Rs.	
1929	32 498 947	25 996 899	6 502 048	80
1930	20 650 683	25 085 120	4 565 563	85
1931	25 324 379	23 809 576	1 514 803	94
1932	22 024 355	21 688 864	335 491	98
1933	19 711 602	19 319 240	392 362	98

The increase in net revenue over 1932 is not due to any abatement of road motor competition, which is intense, and little headway can be made without legislation to control road transport and eliminate uneconomic competition.

Measures detailed in the main report have been continued and economies further effected in transportation and maintenance expenses and by the reduction of stocks on hand in the stores. Also, in some instances on branch lines, station masters have been replaced by Ticket Agents paid on a commission basis.

It is felt that very little more can be done in the way of rate and fare reductions, and it is found that any curtailment, for reasons of economy, in passenger train services, is reflected in the receipts. The introduction of a system of canvassing has preserved freight traffic to rail which would otherwise have gone by road.

India.

Broadly, the position outlined in the main report still obtains, and whilst some increases in receipts are recorded, the downward tendency has not altogether been eliminated. Independently of the general depression, fluctuations in

crops are reflected in the carryings of the railway companies. One notable instance is that of sugar, of which production has greatly increased with a consequent addition to the carryings of the railway companies.

Strict economy continues to be practised, savings in staff have been effected and job analysis has produced very tangible results; works re-organisation and standardisation of rolling stock have improved maintenance. Certain uneconomical passenger train services have been withdrawn.

Road competition is active, though its intensity varies in different districts. In one instance co-operation with the bus companies has proved impracticable owing to the unreliability of the latter, whereas elsewhere effective co-operation has been obtained, and through booking of passengers and parcels established with encouraging results. There is still an absence of legislation, but the Railway Board and the Indian Railway Conference Association are giving the question consideration.

Much has been accomplished on H.E.H. the Nizam of Hyderabad's State Railway, where road and rail transport have been co-ordinated under the railway administration with the object of the best utilisation of existing facilities and their development without the wastage of uneconomic competition. Satisfactory results have accrued.

Increased and accelerated services and reduction in waiting times between connecting trains at junctions have achieved a certain measure of success against road transport. On the other hand, though productive of substantial increases in some instances, partial success only can be claimed for reduced fares introduced with the same object, as the increase in business has not always been sufficient to offset the loss in revenue. A feature in the experience of one company in reducing fares to meet competition was that cheap single journey tickets met with more success than cheap return tickets. Short-distance passengers and freight traffic appear particularly vulnerable to road motor competition and devices to combat this have been, in addition to measures already mentioned : guaranteed vans, relaxing conditions of packing and carriage, and reducing rates. With the latter, traffic regained does not always cover the reductions, and greater success would be achieved but for indiscriminate overloading of road vehicles.

Experiments continue to be made with light units and although not invariably satisfactory for the reasons stated in the main report, they have proved useful and it is contemplated to extend their use.

East Indies.

Netherlands East India State Railway.

Year.	Total receipts.	EXPENSES.			Net.
		Working.	Other.	Total.	
	Thou. florins.	*Thou. florins.*	*Thou. florins.*	*Thou. florins.*	*Thou. florins.*
1929	82 739	51 934	6 879	58 813	23 926
1930	70 387	51 416	6 742	58 158	12 229
1931	56 521	44 885	6 616	51 501	5 020
1932	44 276	36 498	5 408	41 906	2 370
1933	34 019	30 526	5 203	35 729	1 710 deficit.
1934	30 264	27 242	6 172	33 414	3 150 deficit.

The effects of the crisis were felt in 1934 even more than in 1933, as is demonstrated by the foregoing figures. In addition to the difficulties experienced owing to the state of world trade, road transport was an active competitor for both goods and passenger traffic, chiefly short distance.

Reductions in rates, both passenger and goods, which have been made, not only with the object of combating road competition but also to encourage local industry, have contributed to the reduced revenues.

Economies have been effected by amalgamation of administrative offices, re-organisation, standardisation and savings in staff and material when this could be done without impairing efficiency.

In order to conserve traffic to the railway company, collection and delivery services have been developed.

Whilst legislation provides for licensing control of charges, maximum loading of different types of vehicles, and a standard of efficiency, it would seem that this control has not been effective in eliminating uneconomic competition. To some extent this would appear to be due to the fact that licences for road vehicles to ply for hire can only be refused in exceptional circumstances and considerable latitude is given to the road hauliers. The Government is conducting further investigations into this problem.

A reduction of fares for certain districts has had the effect of mitigating the transfer of passengers from rail to road. Also with this object, certain reductions in specified return tickets and supplementary charges on express trains have been made.

In connection with goods traffics, reductions in rates to meet road competition have not been systematic, but rather according to circumstances.

The institution of a system of canvassing for freight traffic has met with a measure of success.

New Zealand.

New Zealand Government Railways.

Year.	Gross receipts.	Working expenses.	Net receipts.	% railway working expenses to receipts.
	£	£	£	
1928-1929	7 524 864	6 374 579	1 150 285	84.72
1929-1930	7 473 993	6 848 026	625 967	91.62
1930-1931	6 781 388	6 406 143	375 245	94.47
1931-1932	5 788 965	5 301 653	487 312	91.58
1932-1933	5 339 075	4 833 754	505 321	90.54
1933-1934	5 628 835	4 877 146	751 689	86.65

The net receipts have increased progressively over the last three years, but whereas in the two previous years the improvement was secured solely by reductions in expenditure, in 1934 it was the result of increased business.

Prevailing economic conditions continued adverse to the maximum development of special day and week-end excursion passenger traffic, but numerous such excursions were organised with satisfactory results.

Reduced fares affected the receipts from suburban traffic, but 1934 showed some improvement in revenue, while the number of journeys was the highest since the predepression year of 1930. Passenger traffic as a whole showed an increase of 12.96 % over 1933.

The depressed condition in trade and industry and the necessity for curtailing train mileage made it impossible to develop night travel to the extent desired.

In 1934 freight traffic, both in tonnage and receipts, showed the first increase over the previous year since 1930. The 1934 tonnage was better than that for 1933 by 2.76 % and receipts by 4.42 %. Accelerated freight services have provided many next-morning deliveries.

1933 was an exceptionally heavy year for grain, which, however, passed in considerably decreased quantities in 1934. The principal increases in freight traffic in 1934 were in the products of the mines and forests. Increases were also shown in agricultural products and animals and their products.

Generally speaking, prospects are considerably brighter.

The following table shows the working for the last six years of the road motor services operated by the New Zealand Government Railways, from which it will be seen that the net position has improved.

Year.	£
1929 net loss of	9 328
1930 » »	11 416
1931 » »	5 842
1932 » »	2 951
1933 net profit of	521
1934 » »	2 368

Road competition, though keen, is to an extent controlled by the Transport Licensing Act, 1931, which was made applicable to goods services by the Transport Goods Order 1933-1934. Thus passenger and goods road transport undertakings are brought within the scope of the Licensing Authority. The stage for granting initial licenses has passed, and applications for renewals now come before the Authority. These are opposed by the railway where the road operator's activity makes for wasteful competition or is in excess of the transport requirements of the district. In this way, the onus of judging the transport requirements of a district lies with the Licensing Authority, and whilst it is true that the railway may appeal against a decision to license a road undertaking which, in their opinion, may be uneconomically competitive, they may find themselves in the position of having a road service authorised which is competitive with themselves, and in these circumstances might consider reducing their own services rather than continue to operate uneconomically. A measure of co-ordination has been achieved, which, in the result, secures economy to the railway and improved service to the public.

Conclusion.

The period of twelve months which has elapsed since I submitted my first report is too short a time for conditions to have materially altered and to judge of the effectiveness of the measures taken by the various railways reported upon. The world depression is of such magnitude and has covered such an extensive period that recovery must be slow. The traffic returns of the various railways dealt with in this report do, however, appear to indicate that the worst period has passed, that the decline in trade has in many countries been arrested and there are signs that in some countries recovery is slowly taking place. The net earning position of the railways is in many instances better, this being primarily due to the economies which have been effected in expenditure.

This supplmentary report will show where progress has been made and may serve to indicate such variations as have occurred during the past twelve months,

also a study of the statistics furnished will reveal almost without comment the position as a whole.

A reflection of the crisis is to be found in the tariff limitations and currency exchange difficulties which greatly interfere with the flow of international traffic, both in goods and in passengers, with consequential effect upon the railways. The effect of monetary problems is particularly noticeable on South American Railways.

The danger of allowing unrestricted and uneconomic competition to exist against the railways is appreciated and definite progress towards the co-ordination of transport resources and the elimination of wasteful competition is being made by means of legislation. Much remains yet to be done, however, before a satisfactory position is reached.

In commenting upon the present position I have had to have regard to the fact that progress is continually being made by the railway companies. In the normal process of their development, new methods are constantly being tried, new designs in equipment are introduced and new experiments are made to attract traffic. The line of demarkation between innovations in normal development and those directly attributable to endeavours to meet the consequences of the world depression is sometimes very fine.

Yet again, when studying traffic receipts of the various colonial railways it is found that there is usually some staple product of the country which provides the bulk of the freight carryings, and whilst it is true to say that the price of the commodity is influenced by the world position, the volume of the crops themselves, and consequently the available tonnage for the railways, may be affected by vagaries in climate totally unerelated to fluctuations in the world market, due to other causes.

Finally, all the evidence goes to show that all the railways the subject of this report continue to face the problem set them by the world crisis with energy and initiative. Experiments are made freely, those which prove successful are continued; those which are not helpful are dropped, unless by their very failure they have contributed something of value.

That some measure of recovery has been attained demonstrates that administrations have flexibility and adaptability and have reacted vigorously to the challenge of the present crisis. In their efforts to deal with the abnormal circumstances they have yet fulfilled their obligations as transport undertakings in the service of the public.

May, 1935.

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION.

INQUIRY INTO QUESTIONS OF IMMEDIATE INTEREST.

(Decision taken by the Permanent Commission at its Meeting held on July 29th, 1933.)

« The World Crisis and Railways

and the effects of the crisis on railway working; measures taken to lessen the effect of the crisis: competition or collaboration between railway and road transport; a forecast of the future; new ideas as to passenger transport, such as light quick trains between large towns and between large and small towns, running at regular intervals. »

SECOND REPORT

(Secondary Railways in Countries of Southern Europe, and their Colonies)

By Messrs E. LAVALLE,

Ingénieur, Directeur de l'Office Technique Central de l'Inspectorat Général des Chemins de fer, Tramways et Automobiles, Rome,

and E. MELLINI,

Ingénieur, Inspecteur supérieur de Vigilance à l'Inspectorat Général des Chemins de fer, Tramways et Automobiles, Rome.

The report we drew up on this question, published in the April 1935 *Bulletin*, p. 365, was written at the end of 1934. The technical and financial results of the 1934 estimates naturally were not available at that time, and all we were able to do was to form an opinion on the tendencies of world traffic as a whole and to examine shortly some of the results obtained during the first part of the year. As the question has to be discussed at the Special Meeting of the Permanent Commission (Brussels, July 1935) and as we are going through a very dynamic period, and a difficult one for the vitality of the railways, who have to adapt their operating methods to meet the increasingly serious demands of a declining traffic and constantly developing road competition, we felt it necessary to prepare a supplementary report dealing with the operating results considered from the same technical and financial aspects, to see if the conclusions of the first report ought to be altered.

The questionnaire given below was submitted to the companies with this object in view, and the numerous replies received have enabled us to complete the data and remarks on the operating results of the last few years in a sufficiently wide and definite way.

QUESTIONNAIRE.

1. In the case of your railway, what effects has the crisis had on the receipts and the vo-

lume of passenger traffic, during the year 1934?

2. What have been the effects on the goods traffic during the same period?

3. Have you adopted any new measures, technical or commercial, to overcome the effects of the crisis, besides those in force in 1933, and with what results?

4. Can you give any new information on motor competition, and has anything been done or new steps taken during 1934 to fight it, or to achieve collaboration between the two methods of transport?

5. Were any new legal enactments put into force in 1934 on the co-ordination of the different methods of land transport, collaboration between road and rail, and facilities of a financial, commercial, and technical nature granted to the railways?

6. Do you wish to stress any conclusions which differ from those drawn up from the replies to the first questionnaire?

The replies of the various Companies are summarised below, the numbers 1 to 6 referring to the different sections of the questionnaire.

A. — Société Générale des Chemins de fer Economiques, Paris.

1. The passenger receipts fell in 1934 by 10.4 % as compared with 1933. The reduction for 1933 on 1932 was 17.1 %.

2. The goods receipts fell by 9.3 % in 1934 as compared with 1933, and 17.1 % in 1933 relatively to 1932.

These figures show that the fall of traffic, both passenger and goods, has slowed down considerably during 1934, but the improvement cannot be taken as indicating the end of the economic crisis through which we are passing.

3. The measures adopted during recent years to lessen the effects of this crisis have been maintained during 1934, especially those in connection with passenger traffic. The fast comfortable railcars put into service on some railways have definitely improved the traffic returns. Two of our railways having a total length of some 500 km. (310 miles), on which the passenger traffic is almost exclusively carried in railcars, have recorded increases in the monthly returns of as much as 35 % on those of 1933, when steam trains were used in the passenger workings.

4. Road motor competition was still felt seriously during 1934. Some co-ordination measures have been taken, these being more particularly in the direction of individual agreements.

5. The Ministry of Public Works set up a Headquarters Co-ordination Committee in April, 1934. The main-line railways, light railways, and road hauliers are represented on it.

This Committee has just ended its inquiry into the co-ordination of passenger transport. The decree putting its recommendations into force has just been published, and by the end of March the Departmental Technical Committees, composed on the same lines as the Headquarters Committee, were nominated and began their labours at once in order to organise the transport of a district in such a way as to eliminate competition. The result of their work will be sent to the Headquarters Committee and to the Minister, who will decide in the last resort.

6. We do not wish to alter the conclusions we gave in our first reply to the questionnaire, the causes of the fall in traffic being unaltered, and the steps taken to meet them as far as possible, not having been changed.

B. — Piedmontese Tramways Company (Saluzzo).

1. The passenger traffic in 1933 and 1934 was as follows :

Passenger receipts	1934	2 183 702	lire
» »	1933	2 444 764	»
Number of passengers	1934	951 259.	
» »	1933	1 065 613.	

2. The goods traffic in 1933 and 1934 amounted to :

Goods receipts . .	1934	1 779 482	lire
» » . .	1933	1 810 406	»
Tonnage	1934	104 478	t.
»	1933	112 834	t.

3. The Company introduced, in 1934, many new facilities in connection with passenger traffic (special fares on holidays, for parties, etc.) and goods traffic.

4. Road motor competition was still keener in 1934 than in 1933. The Company, therefore, entered into agreements with certain road hauliers in an attempt to avoid a rates war.

5-6. The Italian Government passed no further laws, in 1934, in connection with the co-ordination of road and rail transport. The investigations into this question appear, however, to be well advanced. What is really necessary now is equal treatment as between road and rail as regards the legal requirements imposed on them and as regards taxation.

C. — Compagnie Française des Chemins de fer de l'Indochine et du Yunnan.

1. *Passenger traffic.* — Whilst the figures for 1934 are approximate only, it appears that no great correction will have to be made to them, so that they give a general idea of the traffic variation relatively to 1933.

Passengers and luggage.	*1934*	*1933*
Receipts of the Tonquin line . . .fr.	5 748 000	7 319 000
Receipts of the Yunnan line . . . . .fr.	3 363 000	3 438 000
Total. .fr.	9 111 000	10 757 000

The Tonquin line is the only one to have suffered the effects of both the crisis and road motor competition.

2. *Goods traffic :*

Fast goods traffic :	*1934*	*1933*
Tonquin line receipts fr.	1 026 000	1 231 000
Yunnan line receipts fr.	971 000	1 333 000
Total. .fr.	1 997 000	2 564 000

The reduction on the Yunnan line is due to the suppression of certain traffics of an entirely special nature.

The fall on the Tonquin line is due to the combined effects of the economic crisis and road motor competition.

Slow goods traffic :	*1934*	*1933*
Gross receipts . .fr.	26 105 000	26 995 000
Tonnage	231 818	251 240

The tonnage is divided as follows between the main traffic currents :

a) *Traffic not subject to road motor competition :*	*1934*	*1933*
Hai - Fong Docks — Yunnan, transit . t.	26 737	24 802
Yunnan — Hai - Fong Docks, transit . t.	10 012	10 581
Tonquin-Yunnan traffic . . . . . t.	3 383	15 837

(the reduction in the last item is due to particular causes having nothing to do with competition or the economic depression).

Yunnan-Tonquin traffic . . . . . t.	511	437
Local Yunnan traffic . . . . . t.	120 892	122 574
b) *Traffic subject to road motor and waterway competition:*		
Tonquin — Hai - Fong Docks traffic . t. .	26 804	29 712
Hai - Fong Docks — Tonquin . . . t.	17 021	19 630
Local Tonquin traffic . . . . . t.	25 458	27 667

We have nothing to add to the information already given on the other points.

* * *

The following information has been supplied by Companies who did not reply to the questionnaire on which the first report was based.

D. — Nord Milano Railway Company.

1. Passenger receipts for 1934 fell 3.3 % relatively to the 1933 figures. When the change to lower classes, that has occurred, is taken into account, and also the different facilities and reductions granted on holidays, it can be stated with certainty, even though the final results are not yet known, that the number of passengers in 1934 was not lower than in 1933. The 1933 receipts were 9.4 % below those of 1932.

2. The goods receipts for 1934 show a falling off of 6 % on those of 1933, and 28 % as compared with 1932.

The results are different when the tonnages carried are compared. The 1934 tonnage was 1.8 % higher than the 1933 figures, and 18.9 % lower than the 1932 figures. These different results are explained by two facts : the increasing extent to which the highest rated goods are being carried by road, and the reductions in rates and great facilities given by the Company to its best customers to retain their traffic.

3. Both the passenger and goods services have been improved. The timings have been improved and made more convenient. Additional services have been introduced by means of diesel railcars. Very up-to-date coaches, both as regards comfort and attractiveness have been put into service. The speed of the trains has been raised; more excursion trains at very low fares have been run on holidays.

The Company has also introduced a system of premiums in the form of refunds for consignors dispatching more than a given tonnage, and has speeded up the goods working generally.

E. — Rhætian Railway Company (Coire).

1. In 1934 there was a slight increase in passenger receipts through the improved tourist traffic. The receipts, however, fell owing to the reduced fares and also to the ever increasing road competition.

2. The goods receipts fell off slightly too, in spite of the heavier tonnage. The cause is the application of the reduced rates resulting from road transport competition.

5. The Rhaetian Railways are investigating the use of fast light trains, but have not yet come to any definite decision.

The following measures have been taken to meet the ever increasing motor competition : intensive propaganda, improved train connections, shortened journey times, more trains, excursion trains at cheap rates, rates better adapted to requirements, etc.

A law regulating the traffic between rail and road will be submitted to a public referendum in May. The application of this law is expected to result in such a division of the traffic as will prevent any further loss.

F. — Compagnie Générale des Voies ferrées d'intérêt local, Paris.

1. The Company has developed railcar services to the greatest possible extent, the vehicles being designed for each particular case. It intends to retain steam services for working goods traffic only.

At the present time, under normal traffic conditions, 14 locomotives are kept in steam instead of 28 as formerly. The building programme will enable this number to be reduced to 11 normally. As regards the railcar services, by means of which the journey times have been reduced by as much as 40 %, the Company has made provision for hauling a certain tonnage by the rail-

cars whenever this would make it unnecessary to run a steam train.

The results obtained are interesting.

As an example, on a 200-km. (124 miles) group of lines requiring 10 engines in steam, reduced to 5 when 6 railcars were put into service, the locomotive running costs properly speaking, i.e. fuel, lubrication, paraffin, cleaning materials, etc., and enginemen, have fallen from 2.60 francs to 1.395 francs per kilometre.

In addition, considerable savings have been effected in the cost of repairs.

2. The number of combined rates with the main lines has been increased and special rates have been introduced whenever possible and useful.

As regards co-ordinating land transport, new legislation has been introduced, such as the decree of the 19th April, but it is quite recent and has received no practical application up to the present time.

G. — National Railways Company, Lisbon.

1. — *a*) The volume of the passenger traffic during the years 1933 and 1934 was as follows :

1933	*1934*
459 497	476 652

b) The corresponding receipts were :

1933	*1934*
2 482 183.61	2 561 309.62

2. — *a*) Volume of goods traffic during the years 1933 and 1934 (in kgr.).

1933		*1934*	
Fast.	*Slow.*	*Fast.*	*Slow.*
6 337 819	159 512 709	5 795 149	171 655 294

b) The corresponding receipts were :

1933		*1934*	
Fast.	*Slow.*	*Fast.*	*Slow.*
586 201.00	4 007 835.14	541 881.07	4 204 346.92

3-4. — To meet the effects of the crisis and road competition, the Company has contracted with big consignors in the districts served by its lines, and is considering a further general reduction of its rates for certain commodities which, forming the main traffic over its lines, have suffered especially from the crisis and competition.

The Company, too, has contracted for the regular cartage between its stations and the cities and towns it serves, in order to meet road competition.

5. The Portuguese Government passed the laws Nos. 23498 of the 24th January, 1934, and 23499 of the 6th February, 1934, regulating heavy lorry services and road competition.

6. The Company has no new conclusions to suggest on the question considered.

H. — Pireaus-Athens-Peloponnese Railway Company, Athens.

1. The following observations have been made, comparing the 1934 results with those of 1933.

The number of passengers has varied but little, the reduction only being 0.7 %. The passenger receipts, however, have fallen 8 %. This is due (*a*) to the Company having to reduce, in order to retain its customers, the rates still further in the form of reductions on return tickets, and (*b*) by the average passenger journey having fallen 4 % relatively to 1933 (1933 was 5 % less than 1932), through the ever-increasing radius of action of the competing road motor.

2. In goods traffic, the volume carried has fallen 4 % and the receipts 1.3 %, this being due to the slight increase, undoubtedly quite symptomatic, in the average distance carried; the position is in fact stationary and is definitely below the results of the best of the last five years.

3. No new measures were introduced in 1934.

4. Amongst the methods under consideration to meet road competition, the chief is the purchase of high- and low-power railcars, and these will soon be in service.

No steps have been taken to collaborate with the other methods of transport, chiefly because road competition is due not to companies operating road transport services but to individuals owning only one lorry, rarely two, and who are, moreover, in competition with one another.

5. The only provision enacted is the obligation placed on everybody wishing to operate road vehicles between any two places, to obtain beforehand an authorisation from the competent licensing authority. This authorisation is only granted provided the maximum transport facilities laid down by a commission set up by law for each line have not yet been reached.

6. Nothing new to add.

* * *

Finally the whole of the Italian secondary railways suffered a fall in receipts in 1934. Though there has been a slight reduction in working expenses, the position remains critical, in spite of all the work done, as the following figures show :

	1933	*1934*
Length of lines operated . . . . km.	5 924.722	6 100.000
Operating receipts per km. . . . . lires	30 855	27 265
Operating expenses per km. . . . . lires	36 925	35 151
Working coefficient .	1.20	1.29

The information collected, broadly speaking, confirms the conclusions of our report of December 1934-XIII.

Rome, May 1935-XIII.

[621. 43]

A contribution to the comparative study of the different types of electric transmission used on diesel-electric railcars,

by E HENNIG,
Engineer, Belgian National Railways Company.

In principle, the function of the electric transmission of diesel-electric railcars (and locomotives) is to so apply the power produced by the diesel engine to the driving wheels that, for a given fuel injection (volume injected per revolution), this power remains practically constant whatever the running conditions of the vehicle. This constancy is due to the particular running conditions of the diesel, the angular speed of which cannot fall below a certain limit without upsetting its working and its good preservation.

The above conditions necessarily imply constant power at the driving wheel treads, i.e. a constant value of the product of tractive effort multiplied by vehicle speed. For this power to remain constant in spite of the variations of the tractive effort and the vehicle speed, ignoring variations in the efficiency of the electric transmission, the product $E \times I$, of the voltage at the generator terminals by the current produced, must also remain constant.

Now, the electric traction motors, series excitation, usually fitted to railcars, develop a driving torque (tractive effort) almost proportional to the current absorbed, in other words these motors all the time take a current which varies with the tractive effort developed. The generator output cannot therefore be controlled as regards intensity, but only as regards voltage.

Under these conditions, if for a given fuel injection the product $E \times I$ is to be constant at the generator terminals, the voltage of the current delivered must be made to vary inversely as the current intensity : to a high intensity (high tractive effort) must correspond a low voltage, and vice versa, for a low intensity (small tractive effort) the corresponding voltage should be high.

* * *

When so stated, the problem is to design a generator so that for a given working power of the generating set, the curve $E = \varphi (I)$ of the voltage at the generator terminals in terms of the current intensity generated (external characteristic of the generator) is an equilateral hyperbola relatively to its asymptotes as axes of the co-ordinates (fig. 1).

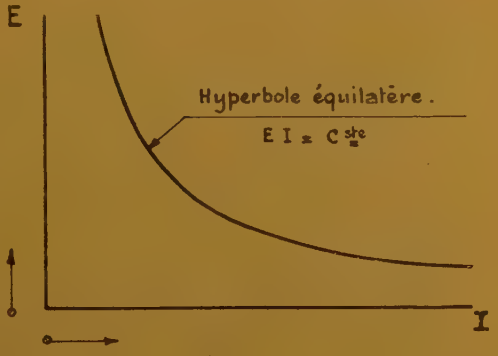


Fig. 1.

If the current demand of the traction motors be considered as an independent variable, and if the fact, that the voltage of the generator is directly proportional to its speed of rotation and to the field, be taken into account, the problem is to vary this field in inverse ratio to the intensity of the current generated, the angular speed of the set being maintained constant by the centrifugal governor of the diesel engine (called « constant speed system »), or being allowed to vary between narrow limits (known as « variable speed system »).

This result can be obtained either by :

I. a device modifying the excitation of the generator according to the load thereon (systems known as « external control of the generator field »);

II. using an exciter supplying the generator with an exciting current varying with the vehicle speed;

III. employing a self-regulating generator, with a special characteristic approaching more or less closely the equilateral hyperbola.

I. — Systems in which the generator field is varied by external means.

This can be done :

— Either by inserting a *field rheostat* which alters the excitation of the generator, this rheostat being hand-operated in non-automatic transmissions such as the Ward-Léonard and the A. S. E. A., or automatically controlled by the variation of the main current strength as in the Ward-Léonard transmission made by the Compagnie Electro-Mécanique, the Thrige Company, and Messrs. Brown-Boveri (Mannheim) and Brown-Boveri (Baden), etc.

With these systems, the diesel is controlled by the centrifugal governor which maintains the engine speed constant for a given working power.

— Or by the automatic action of a *torque regulator* which, under varying loads on the generator, modifies the excitation of the generator by cutting out or inserting resistances in the excitation circuit, as in the Westinghouse system (variable speed).

— Or again by the automatic intervention of a *regulating motor* which alters the excitation of the generator according to the variation in the main current strength, as in the A. S. E. A. automatic transmission (constant speed).

The A. S. E. A. and Ward-Léonard non-automatic systems, use :

a) either a self-exciting shunt-wound generator (fig. 2) as in the A. S. E. A.

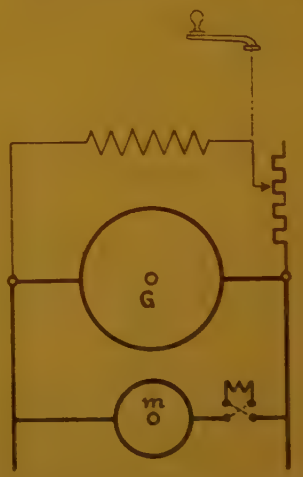


Fig. 2. — The A. S. E. A. non automatic transmission. — Principle of design.

non-automatic system used on the Belgian 200-H.P. diesel-electric railcar working on the Pepinster-Spa line. The exciting current is hand-controlled by a field rheostat in the generator shunt exciting circuit;

b) or a generator, the exciting current for which is supplied by an auxiliary dynamo (exciter) (fig. 3).

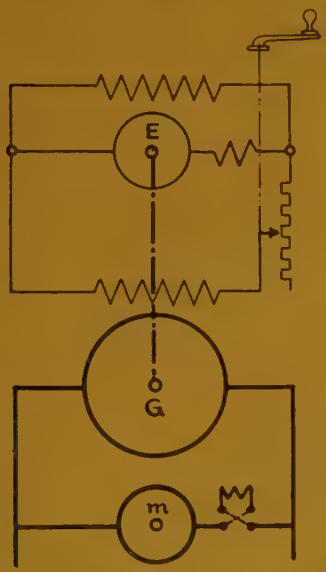


Fig. 3. — The Ward-Léonard non automatic transmission. — Principle of design.

The non-automatic Ward-Léonard systems are of this kind. The exciting current is hand-regulated by a field rheostat inserted in the external circuit of the exciter.

The automatic Ward-Léonard systems use :

a) either a generator with completely independent excitation, as for example in the automatic transmissions made by Messrs. Brown-Boveri (Mannheim), the Electro-Mécanique Company, and Messrs. Thrige, etc.

b) or a generator with separate excitation and shunt self-excitation, as in the Brown-Boveri (Baden) automatic transmission.

In these systems the current for the separate excitation is also supplied by an auxiliary generator (exciter), coupled to the shaft of the main generator, but in this case the excitation is regulated *automatically* by a field rheostat (drum type of excitation controller) inserted in the external circuit of the exciter and depend-

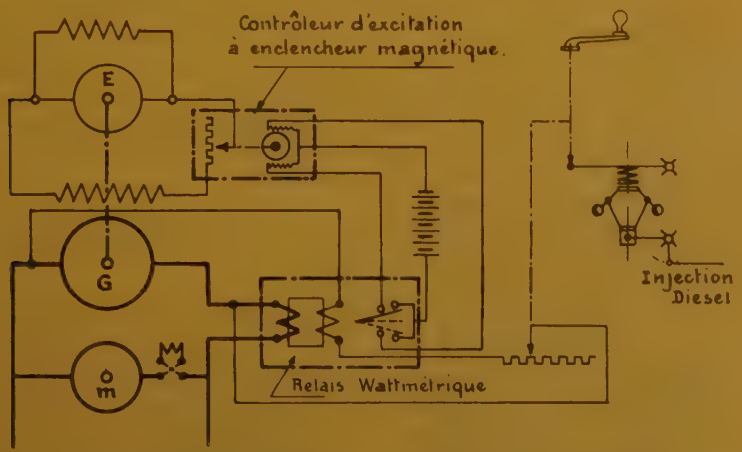


Fig. 4. — The Brown-Boveri (Mannheim) transmission. — Principle of design.

Note : Contrôleur... = Excitation controller with electromagnetic interlocking. — Relais... = Relay of wattmeter type.

ing on the main current. This is achieved :

— either, as for example in the Brown-Boveri (Mannheim) system (fig. 4), by a power relay (wattmeter type) operating the drum of the excitation controller through a magnetic interlocking;

— or, as for example in the Brown-Boveri (Baden) system (fig. 5) by an arrangement which couples together the

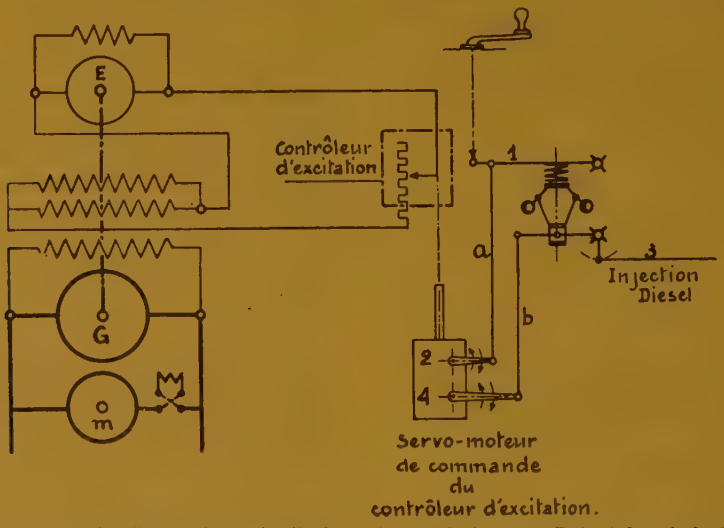


Fig. 5. — The Brown-Boveri (Baden) transmission. — Principle of design.
Note: Servo-moteur... = Servo-motor controlling the excitation controller.

drums of the exciter controller and the sleeve of the diesel governor through a slide-valve-operated oil pressure servo-motor. With this arrangement, as soon as the intensity of the current taken by the traction motors tends to vary in either direction, the corresponding variation of the generator load tends to upset the equilibrium of the diesel governor. The sleeve of the latter immediately acts on the injection of the diesel (through the rods *3*) and on the drum of the excitation controller (through the rodding *b* controlling the distribution valve *4* of the oil-pressure servo-motor).

This twofold action immediately re-establishes the balance momentarily upset. The torque of the generator to obtain a desired power is controlled by means of the excitation controller through the rodding (1) varying the tension of the governor spring. This rodding is connected by a spindle *a* to the control of a cam shaft (2) regulating the action of the servo-motor on the excitation controller drum.

In the Westinghouse automatic transmission (fig. 6) the generating set includes :

— a main generator (1), separately excited;

— an auxiliary exciting generator (2), self-exciting;

— a tachometric generator or magneto (3) with permanent magnets.

These three machines are coupled to the diesel crank shaft.

The auxiliary generator (2) supplies the exciting current to the main generator and charges an accumulator battery for the auxiliary services.

This exciter is compound-excited so that the voltage it generates is constant for each angular speed of the set, whatever the load on the main generator. It has, in addition, a decompounding series winding which limits the current when the battery is being charged.

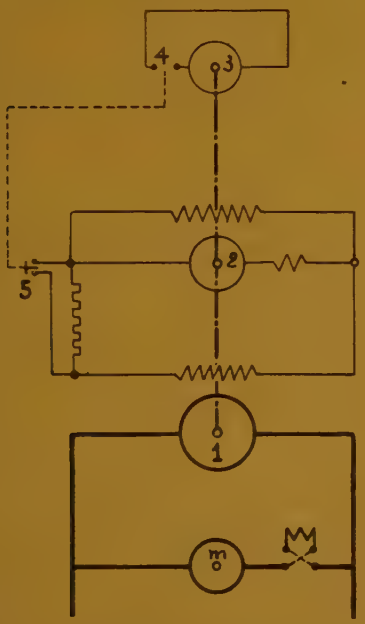


Fig. 6. — Principle of the Westinghouse transmission.

The voltage of the current supplied by the tachometric generator is proportional to the rotational speed of the set. This generator operates a voltage relay (4) which controls a contactor (5) acting on a regulating resistance *r* inserted in the separate exciting circuit of the main generator. As soon as the balance between the resisting torque of the main generator and the driving torque of the diesel is upset, owing to a variation in the load on the main generator, the resulting variation in the angular speed varies the voltage of the tachometric generator. According to the case, the voltage relay (4), owing to this voltage variation closes or opens the contactor (5), which either short-circuits or brings into the circuit the excitation regulating resistance of the main generator. By these means, the voltage at the terminals of this latter changes sufficiently for equilibrium to be re-established almost immediately with but a slight change in the engine speed. In short, the automatic action of the tachometric generator regulates the field of the main generator so that for the same power output the voltage across the latter's terminals varies as the current delivered, according to a hyperbolic law.

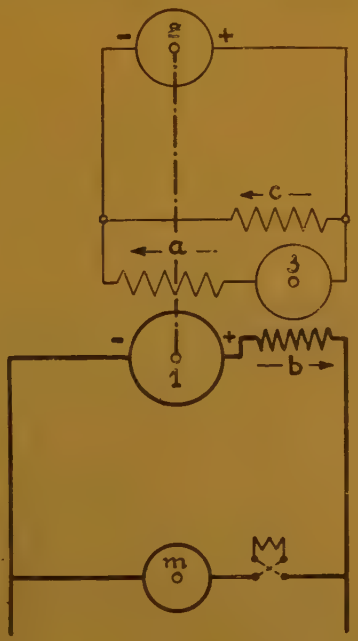


Fig. 7. — Principle of the A. S. E. A. automatic transmission.

The A. S. E. A. automatic system (fig. 7) uses a main generator (1) the exciting current of which (winding *a*) supplied by an auxiliary constant-voltage exciting generator (2) coupled to the main generator, is automatically governed by a regulating motor (3) inserted in the external circuit of the exciter. This regulating motor has two exciting windings : one (*b*) through which the main current flows, the other (*c*), in opposition, fed by the constant-voltage current of the exciter. The difference between the constant-voltage of the exciter and the voltage of the regulating motor (counter-electromotive force varying with the amperage of the main current) sets up, in the main generator, a flux which changes very closely inversely as the strength of the main current.

This device is very simple and entirely automatic; it has been fitted to a railcar built by the Aciéries du Nord Company for the French Nord Railway.

II. — Systems with exciters the voltage of which varies with the vehicle speed.

A transmission of this kind has been designed by the « Forges et Ateliers de Constructions Electriques de Jeumont », and will be used on 5 high-speed triplet railcars for the Belgian National Railways Company.

This transmission (fig. 8) has a main generator (1), the exciting current of which (winding *a*) is supplied by an exciter (2) *driven mechanically by one of the axles of the railcar*. The speed of rotation of this exciter is therefore proportional to that of the traction motors (*m*). The same exciter possesses a shunt winding (*b*) and a separate exciting winding (*c*) fed by an accumulator battery (3). The latter in turn is charged by an auxiliary generator (4) with shunt excitation (*d*). The main generator (1), and the auxiliary generator for battery charging (4) are coupled to the diesel engine shaft.

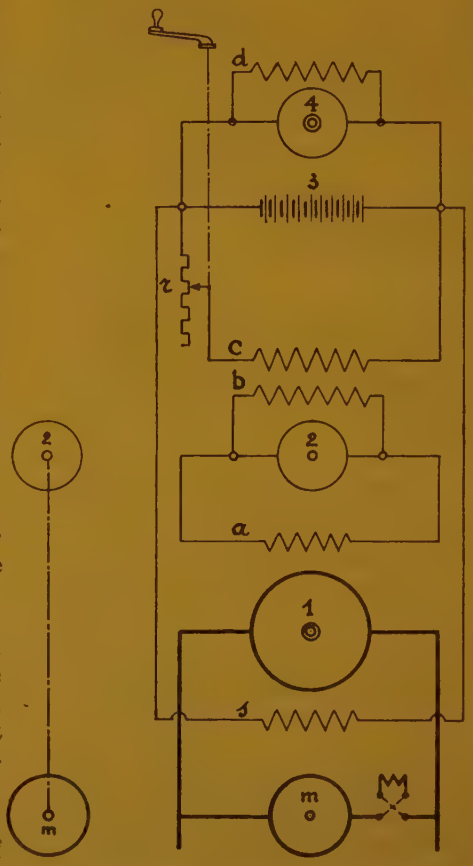


Fig. 8. — Principle of the Jeumont transmissi

To get the railcar to start (the exciter not yet giving any current and the main generator not having sufficient residual excitation), the main generator has a special separate exciting winding (*s*) then fed directly by the battery.

When the railcar has been started, the driver regulates for each power stage needed, the diesel speed and torque, and the resisting torque of the main generator, by varying the amount of fuel injected and at the same time by altering the excitation by means of the field rheostat (r) in the separate exciting circuit of the exciter.

For each power stage set in this way, the exciter running at an angular speed proportional to that of the electric traction motors (and therefore inversely proportional to the current they are taking) then alters for all cases the flux of the main generator inversely as this current intensity, i.e. according to a hyperbolic law.

With this system, the whole power of the diesel can be used within wide variations of working conditions of the railcar. It, therefore, corresponds to particularly favourable working conditions, in this respect, and is free from the defects inherent in systems using magnetic interlockers, current relays, voltage relays, wattmeter-type relays, which are all liable to failure.

III. — Systems with self- regulating generators.

When a self-regulating generator is used, two cases are to be considered :

A) The excitation method adopted only gives a characteristic curve following more or less closely the hyperbola so long as the angular speed can vary between certain limits (systems known as « variable engine speed systems »). In this case the angular speed must be allowed to vary, so that under the simultaneous variations of the main current and the revolutions per minute of the set, the generator voltage can regulate itself on this current following an approximate hyperbolic law.

The allowable variations of the angular speed (about 5 %) act to some extent as a corrective, the diesel centrifugal governor only coming into action to prevent the rotational speed of the set from exceeding the limits laid down by the diesel engine builder for each power stage.

B) The generator is provided with a special excitation leading up straightaway to almost a perfect hyperbolic characteristic, as the number of revolutions per minute can remain constant for the power stage considered. The diesel centrifugal governor now only acts to limit the angular speed of the set to its absolute maximum, the constancy of the engine speed corresponding to a given power being assured by the dynamic equilibrium between the driving torque (the diesel) and the driven torque (generator).

A. — Case in which the angular speed of the group is necessarily variable.

In a general way, transmissions of this kind (Oerlikon, Gebus, Lemp, R. Z. M., etc.) function as follows :

If the external characteristic $E = \varphi (I)$ of a shunt-wound self exciting or

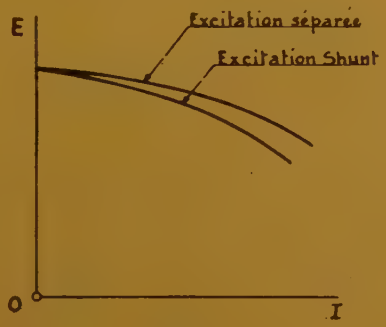


Fig. 9.

Note: Excitation séparée = Separate excitation. — Excitation shunt = Shunt excitation.

independently excited generator be considered, such a characteristic is seen to show a slight voltage drop with the increased current generated. This drop of voltage is greater with a decompounded generator (fig. 10), the effect of the opposing series winding weakening the generator field as the intensity of the main current through this winding grows. By suitably designing the windings, it can be ensured that for a given speed (r. p. m.) of the set a characteristic curve of the kind cuts, at two points (such as A and B) lying at the limits of use of the current generated, the constant power hyperbola corresponding to the speed (r. p. m.) (fig. 11) decided on. These two points — known as points of equilibrium — relate to the two values I_A and I_B of the current intensity generated at which the diesel power is fully used.

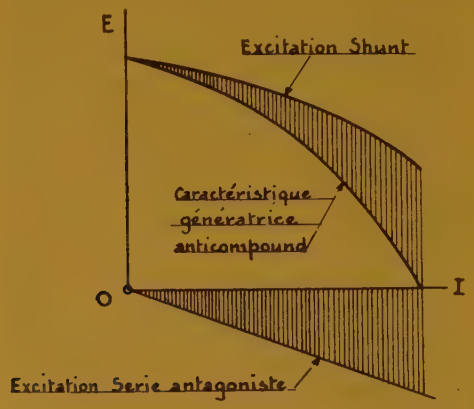


Fig. 10.

Note: Caractéristique... = Characteristic curve of decompounded generator. — Excitation serie antagoniste = Decompounding series excitation.

Against this, the same figure 11 also shows that :

a) for values of the current below I_A or above I_B, the generator does not use the full power of the diesel;

b) for current values lying between I_A and I_B, the generator tends to absorb more power than the diesel can develop. In other words, the resisting torque of the generator tends to become greater than the driving torque of the diesel engine, one of these machines always revolving at the same speed as the other. As a result, the equilibrium is upset and were it not for the effect of the permissible variation in the angular speed,

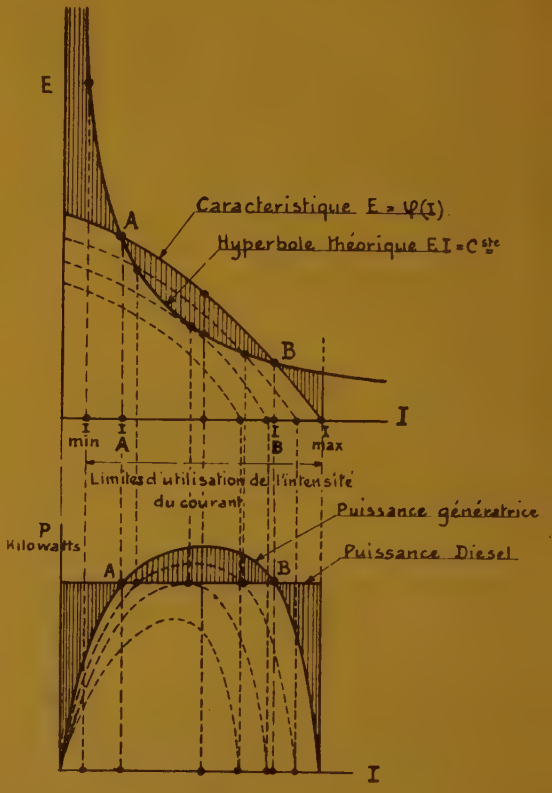


Fig. 11.

Note: Caractéristique E... = Characteristic curve E = φ (I). — Hyperbole théorique... = Theoretical hyperbola EI = constant. — Limite d'utilisation = Limits between which the current intensity can be used. — Puissance génératrice = Generator power. — Puissance Diesel = Diesel engine power.

the generator acting as a brake, would end by stalling the diesel.

In order to have steady running for all values of the current intensity between the limits I_A and I_B corresponding to the points of equilibrium A and B, the resisting torque of the generator must balance the driving torque of the diesel before there is any great variation in the speed of the set. In other words, when the angular speed of the group tends to change through the state of equilibrium being upset, the power absorbed by the generator must change quickly enough to permit a fresh state of equilibrium being established at once, at a slightly different angular speed. This condition necessarily involves a relatively rapid variation of the voltage for a small variation of the angular speed of the group.

The process will then be as follows :

Let us suppose that to a value I_1 of the main current there corresponds for a number N_1 of revolutions per minute a point of equilibrium 1 shown by the intersection of the characteristic curve E_1 with the equilateral hyperbola P_1 (fig. 12).

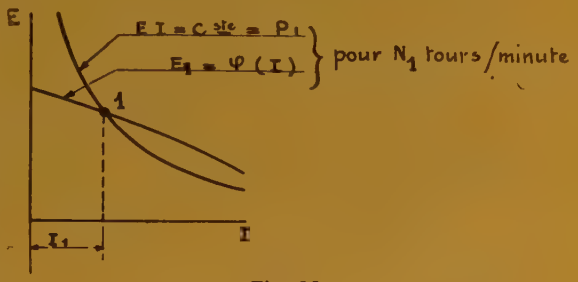


Fig. 12.

Note : Pour N_1,... = for N_1 r. p. m.

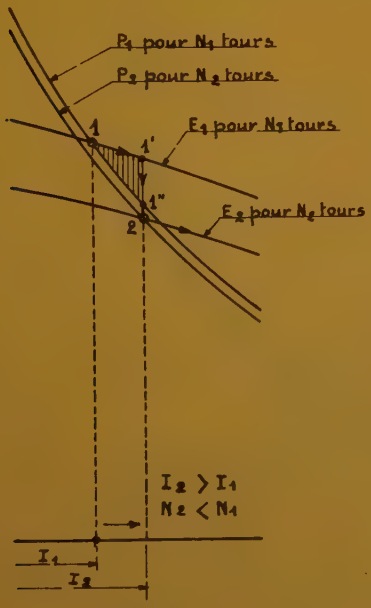


Fig. 13.

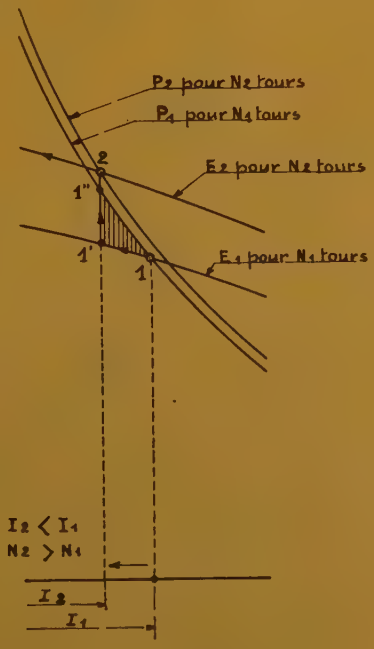


Fig. 14.

Two cases have to be considered according as the current increases or diminishes :

First case :

As soon as, owing to an increase in the tractive effort, the current intensity tends to increase (fig. 13) the voltage (1) tends to diminish according to the characteristic curve E_1 and to regulate itself to a value (1′) higher than that of the ordinate (1″) of the hyperbola. There is then a lack of equilibrium between the resisting torque of the generator and the driving torque of the diesel, the first being higher than the second. Immediately the number of revolutions per minute tends to fall. But if, as is necessary, the corresponding drop of voltage is sufficiently quick, a new state of equilibrium (2) will be set up before the number of revolutions has fallen very much, as for example from N_1 to N_2, the number of revolutions N_2 being little different from N_1.

And so on.

Second case :

The opposite occurs as soon as, owing to a reduction in tractive effort, the current tends to diminish (fig. 14). The voltage (1) tends to increase according to

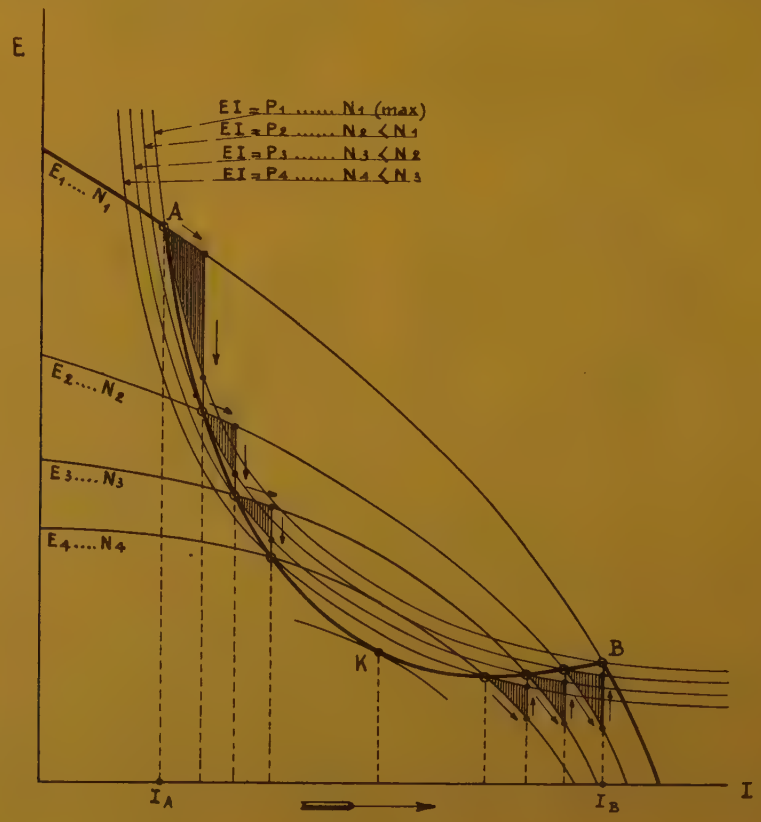


Fig. 15.

the characteristic curve E_1 and to regulate itself to a value (1′) lower than (1″) of the ordinate of the hyperbola, so that this time the driving torque of the diesel is higher than the torque of the generator. Immediately the number of revs. per min. tends to increase. But if, as is necessary, the corresponding increase in voltage is sufficiently rapid, a new state of equilibrium is set up before the number of revolutions has increased very much, as for example from N_1 to N_2, there being little difference between the number of r. p. m. N_1 and N_2.

And so on.

Under these conditions, the main current varying from I_A to I_B or from I_B to I_A:

1. If the current increases from I_A to I_B (fig. 15), the successive states of equilibrium will be arrived at a follows :

a) firstly by successive overloadings of the diesel engine, so that the number of revolutions decreases from the maximum value N_1, corresponding to the point of equilibrium A, to a certain minimum value (point of equilibrium K);

b) then, by successive reductions of load on the diesel, so that the number of revolutions increases this time from the

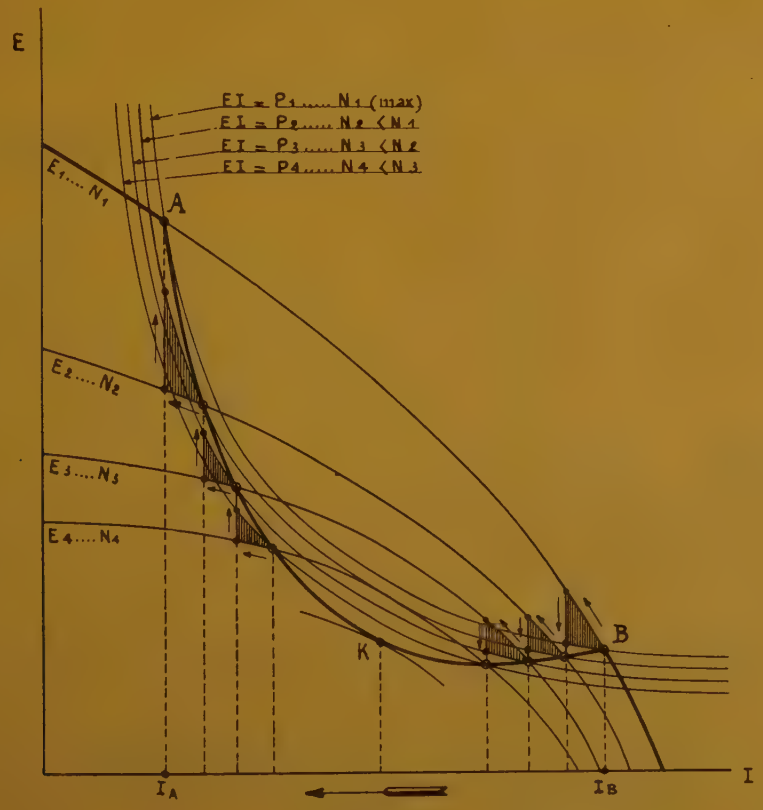


Fig. 16.

minimum value, and again reaches the maximum value N_1 corresponding to the point of equilibrium B.

2. If contrariwise, the current decreases from I_B to I_A (fig. 16), the successive states of equilibrium are still set up :

a) at first by successive overloadings of the diesel engine, with a decrease in the number of revolutions to the minimum value corresponding to the point of equilibrium K;

b) then by successive reductions in load on the diesel engine, with increase in the number of revolutions to the maximum value N_1 coresponding to the point of equilibrium A.

When referred to the ordinates of the hyperbola (P_1) corresponding to the admissible maximum number of revolutions N_1 for the power output considered (fig. 17), the differences between these ordinates and those of the characteristic curve A K B when working at a variable angular speed, represent, in relative value (%), the « degree of reduction of the angular speed and the power » of the diesel engine, that is, in other words, the measure of the falling off in the use made of the power of the diesel (« Druckung »).

1. — *Oerlikon transmission* (fig. 18).

The Oerlikon Company have endeavoured to obtain, if not perfectly constant power absorbed by the generator, at least a great simplicity in order to reduce the electrical equipment to a minimum weight.

In principle the generator is a shunt wound self-exciting one. In order to avoid the difficulties in starting the generator, however, the field winding of the latter is used during the starting of the railcar as a separate excitation winding fed by a battery of accumulators.

When the railcar has been started, the generator acts as a shunt-wound self-exciting generator, and recharges the battery.

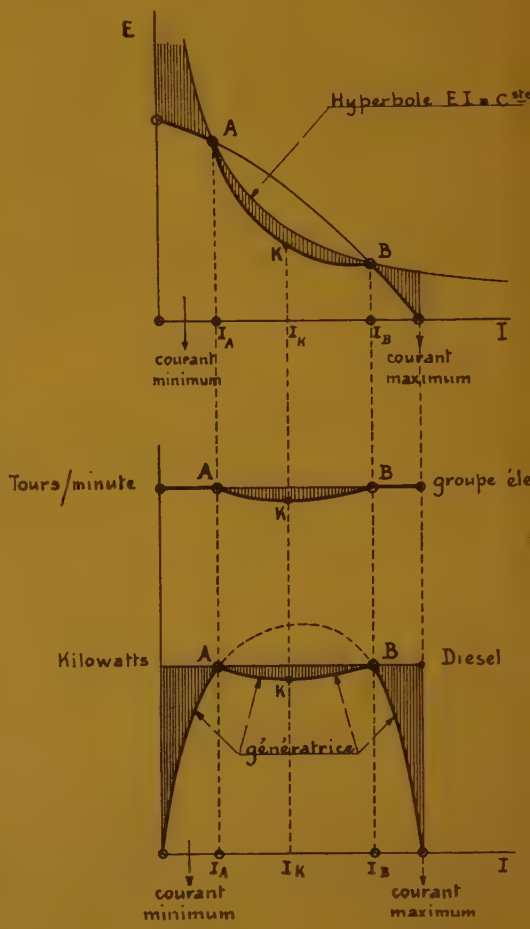
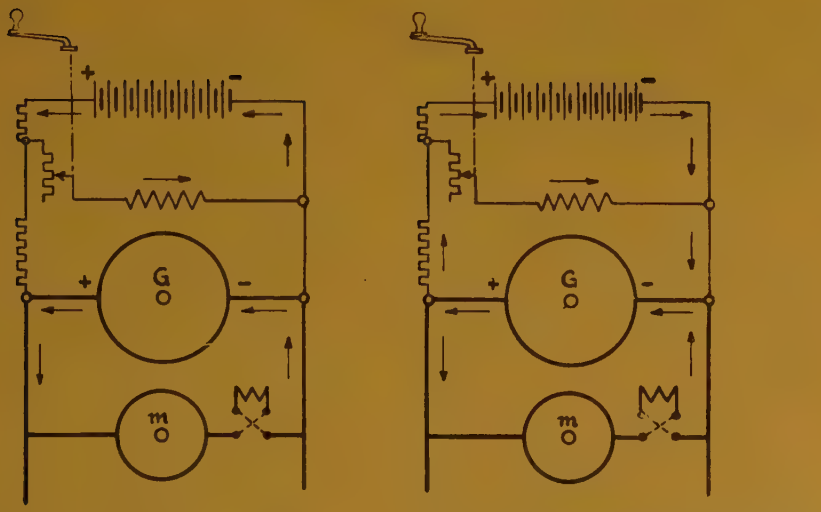


Fig. 17.

Note : Courant minimum (maximum) = Minimum (maximum) current. — Tours/minute = R. p. m. — Groupe électrogène = Generator set.

A resistance controlled by a hand-operated rheostat is inserted in the excitation circuit in order to enable the driver to select a given working power.



Generator acting as separate excitation (starting).

Generator acting as shunt-wound self-excitation and for charging the battery (full speed).

Fig. 18. — Oerlikon transmission. — Principle of design.

2. — *The Gebus transmission* (fig. 19).

This system, also very simple, uses like the Oerlikon system, a shunt-wound self-exciting generator. However, instead of using a battery of accumulators to facilitate starting up the generator, the Gebus Company has given the generator a series winding so designed that its field only affects the generator for heavy main-current intensities, that is to say when the railcar is started.

In addition, the Gebus generator only works in the non-saturated parts of its magnetisation curve, a region lying at the end of the most markedly inclined part of this curve and at the beginning of the bend connected to this part. Under these conditions, slight variations in the angular speed can produce sufficiently rapid variations of voltage, so that each time the dynamic balance is disturbed, a new point of equilibrium at a slightly different speed is arrived at very soon.

A field rheostat acting on the adjustable resistances inserted in the shunt winding of the generator, the operating of which is linked up with the control, by the electric servo-motor, of the ar-

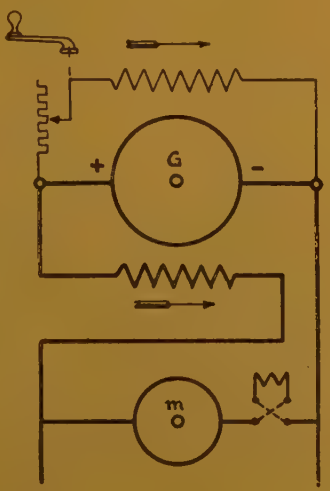


Fig. 19. — Gebus transmission. Principle of design.

rangement for adjusting the tension of the spring of the diesel centrifugal governor, enables the driver to select one of a number of ranges of working powers.

3. - *The American « Lemp » transmission of the A. E. G.* (fig. 20).

The main generator (1) has two field windings A and B, fed by an auxiliary generator (exciter) (2) excited by a battery of accumulators (3).

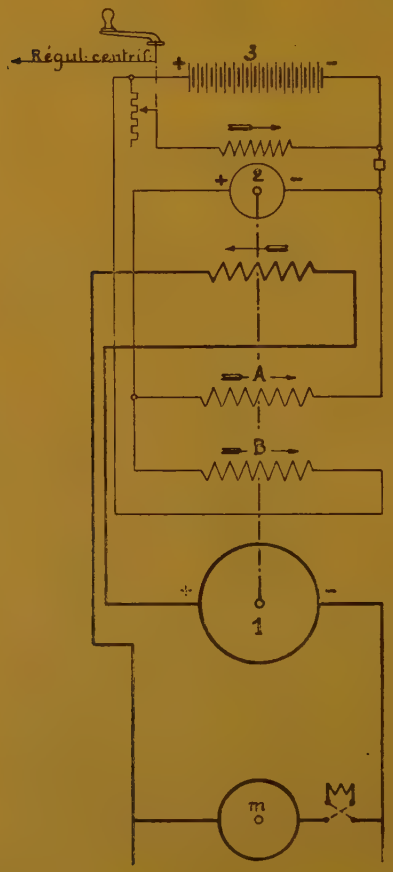


Fig. 20. — American « Lemp » transmission. Principle of design.

The main generator and the exciting generator are coupled to the diesel engine crank shaft.

One of the field windings (A) of the main generator is connected directly to the terminals of the generator. The other (B) connected in parallel on the winding (A), is coupled to the terminals of the battery which can in this way be charged by the exciter.

In addition the exciter is decompounded by the main current, which has the effect of accentuating the dipping form of the characteristic curve of the main generator.

Finally, thanks to this method of excitation slight variations in angular speed are sufficient to induce sufficiently rapid variations of voltage at the terminals of the main generator, these variations in speed reacting at the same time on the pressure of the exciter governing the field of the main generator and on the voltage of the latter.

As regards starting the railcar, this is assisted by bringing in the battery to excite the exciting generator.

A. — *Standard R. Z. M. transmission of the Reichsbahn* (fig. 21).

Based on the American « Lemp » transmission and the « Gebus » transmission, the Reichsbahn has introduced a standard system the principle of which is the following :

The main generator (1) with combined anticompound excitation (fig. 21) has three windings, namely :

— a separate winding (*a*) fed by current from an auxiliary generator (exciter) (2) coupled to the generating set and acting as compound self-excitation;

— a shunt winding (*b*);

— a series winding (*c*) in opposition to the two preceding ones.

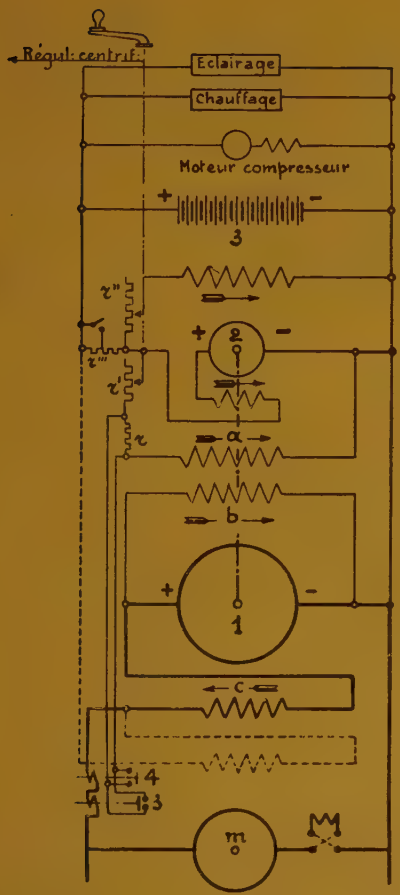


Fig. 21. — R. Z. M. transmission of the Deutsche Reichsbahn. — Principle of design.

Note: Regul. centrif. = centrifugal governor. — Eclairage = lighting. — Chauffage = heating. — Moteur compresseur = motor compressor.

Through this arrangement any increase in intensity of the main current causes a corresponding weakening of the field due to the separate — excitation and shunt — excitation windings. The voltage at the terminals of the main generator decreases very appreciably when the main current increases, and vice-versa, which makes the characteristic curve of the generator fall very sharply (fig. 22).

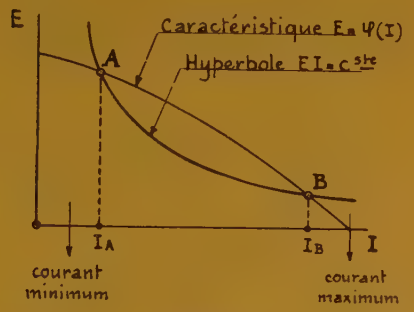


Fig. 22.

As in the Lemp system, the influence of the variation of the angular speed on the voltage at the terminals of the generator is also particularly marked, because the exciter being coupled to the shaft of the main generator, any voltage variation of the former of these machines accentuates the voltage variation of the other.

A particular feature of the R. Z. M. system lies in the means devised by the Reichsbahn to diminish the degree of reduction in speed and power of the diesel between the limits within which the power is fully used, defined by the points of equilibrium A and B (fig. 22). This is done with the object of spacing these limits more widely.

The programme the Reichsbahn set itself required, indeed, a standard system of transmission (Einheitssystem), which could adapt itself with the same flexibility both to local services requiring high acceleration and to through express services. This condition necessarily implied that the points of equilibrium A and B be as far apart as possible, the point A then lying in the zone of the low currents used at high running speeds of the rail-car, and point B in the zone of the high

current intensities used at low running speed. However, as figure 23 shows, the degree of reduction of speed and power of the diesel (cross-hatched zone) is more pronounced as the distance between the

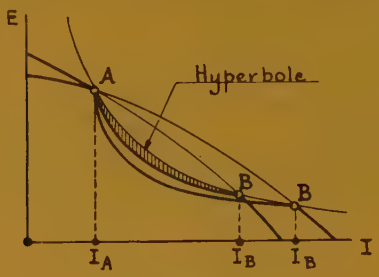


Fig. 23.

abscissæ of the points of equilibrium A and B is greater. To overcome this difficulty, the Reichsbahn has devised a means for automatically weakening the field of the generator between two intermediate values of the current delivered, lying between the extreme limits of use of this current. Thanks to this method, the generator acts, for a given number of revolutions per minute, according to two different characteristics such, for example, as E_1 and E_2 : one with full excitation, and the other with reduced excitation. This latter cuts the hyperbola of maximum power for the working conditions under consideration at two points C and D to which correspond two other states of equilibrium on the same hyperbola. The generator acts then according to the effective characteristic curve A A′ C K D B′ B (fig. 24) and the degree of speed and power reduction of the diesel is only that shown by the cross-hatched zone.

The weakening of the excitation of the main generator is obtained, at the desired moment, by the automatic cutting in of the two current relays 3 and 4 (figs. 21 and 24), which causes a resistance *r* being inserted into the separate exciting circuit.

When the railcar is starting, the main current is a maximum and the relay *3* is released so that, the resistance *r* being short-circuited, the generator runs with full excitation.

The running speed of the railcar then increasing progressively, at the moment at which the decreasing current has fallen to the value I_D, the relay *3* is released, which inserts the resistance *r* and the generator works with reduced excitation. When the current has only the value I_C, the relay *4*, up to then in the released position, is closed in its turn and re-establishes the short-circuiting of the resistance *r*, so that from this time the generator again works at full excitation.

A similar process takes place when, for example, the railcar running onto a rising gradient, the current demanded by the traction motors steadily increases.

The control by the driver of the working power of the generator for a given volume of injection per revolution also is done — as in most other systems — by means of a field rheostat. For this purpose, resistances *r′* and *r″* (fig. 21) are inserted both in the exciting circuit of the auxiliary generator (exciter) and in that of the main generator fed by this exciter; in addition, the rheostat is operated in conjunction with the remote control for regulating the tension of the spring of the centrifugal governor, upon which depends the volume of injection per revolution and the limit of the corresponding speed of rotation.

Provided the field resistances *r′* and *r″* are properly selected for each working condition, it is possible :

1. to adapt the power taken by the main generator to a degree defined by a

given function of the rotational speed of the set;

2. to obtain that, within certain limits of angular speed of the set, the voltage of the exciter remains sufficiently high at working conditions below this speed. This is necessary, because in the R. Z. M. system, the auxiliary generator (exciter) should at the same time charge the 110-volt battery of accumulators (3) for the auxiliary services and for starting the diesel.

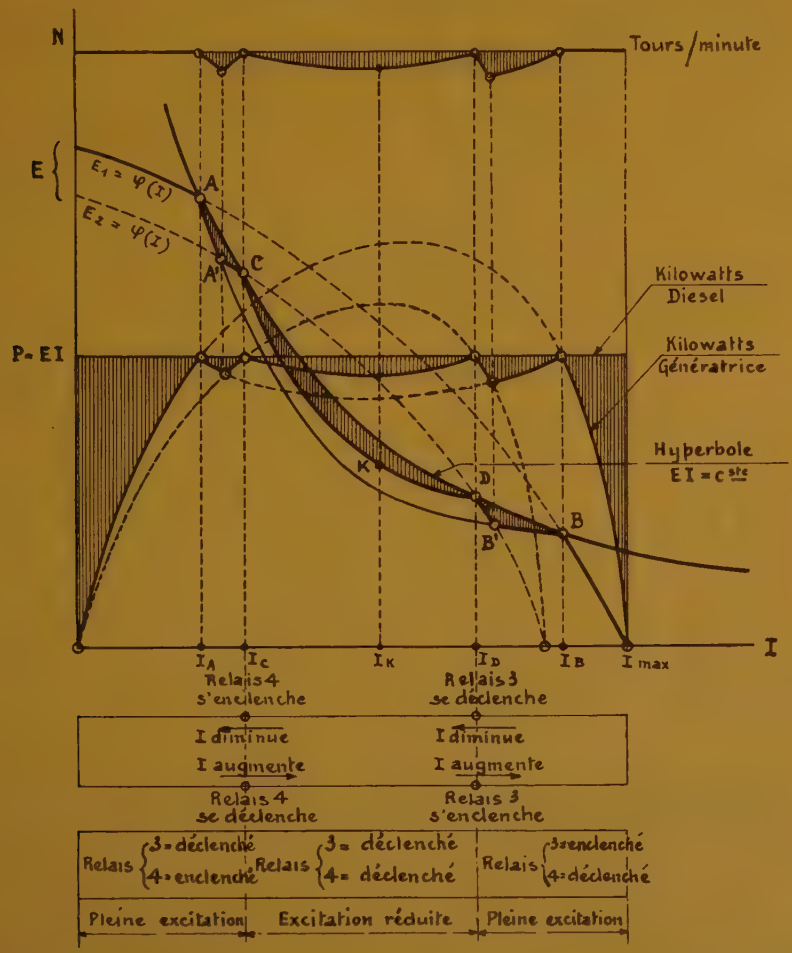


Fig. 24. — Characteristic working curve of the R. Z. M. transmission of the Reichsbahn.

Explanation of French terms:

Tours/minute = R. p. m. — Kilowatts (Diesel) = Kilowatts at the diesel. — Kilowatts (Génératrice) = Kilowatts at the generator. — C^ste = constant. — Relais 4 s'enclenche = Relay 4 cuts in. — Relais 3 se déclenche = Relay 3 is released. — I diminue = I diminishes. — I augmente = I increases. — Relais 3 déclenché = Relay 3 released. — Relais 4 enclenché = Relay 4 on. — Pleine excitation = Full excitation. — Excitation réduite = Reduced excitation.

For this, in the battery-charging circuit, a cut-out switch is inserted which puts the battery on charge when the exciter generates sufficient voltage, or which cuts the battery out of circuit when the voltage of the generator falls below that of the battery.

For the variations of current intensity of the battery, which depend upon the voltage of the latter, not to act upon the voltage of the main generator, and consequently on the power absorbed thereby, the auxiliary generator (exciter) is compounded by a series winding.

In order to protect the battery against possible overcharging — the auxiliary generator supplies a maximum voltage of 150 — a buffer resistance r''' is inserted in the battery-charging circuit.

Finally in order to start the diesel by the main generator acting as a motor fed by current from the battery, the main generator has an additional series winding so that, at that moment, it can run as a series motor.

The R. Z. M. system is used by the Reichsbahn on a large number of railcars, some of which are already in service, but most of which are still under construction; these are :

— 13 eight-wheeled railcars with 300-H.P. diesel engines for main lines (maximum speed 90 km. = 56 miles- an hour);

— 103 eight-wheeled railcars with 410-H.P. diesel engines for main lines (maximum speed, 110 km. = 68.3 miles an hour);

— 13 twin railcars (6 pairs of wheels) with two 410-H.P. diesel engines, for a maximum speed of 160 km. (100 miles) an hour;

— 2 triple railcars (on eight pairs of wheels) with two 600-H.P. diesel engines, for a maximum speed of 160 km. (100 miles) an hour.

B. — **Case in which the rotational speed of the set is not necessarily variable.**

The A. E. G. Company, also inspired by the American « Lemp » system, have improved this design in the following way (fig. 25).

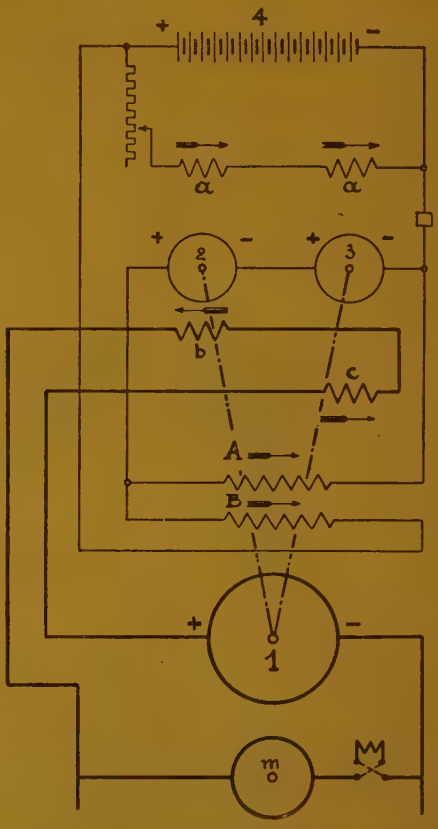


Fig. 25. — A. E. G. transmission with double exciter. — Principle of design.

The self-regulating generator (1) acts, as in the Lemp system, with independent excitation; but in principle the A. E. G. system has two exciters (2) and (3). One of the field windings (A) of the main generator is directly connected to the ends of the two exciters in series whereas

the other (B), in parallel on the external circuit of the two exciters, is connected, as in the Lemp system, to the terminals of a battery of accumulators (4). The two exciters possess a common field winding (*a*) fed by current from this battery.

One of the two exciters (2) is strongly decompounded by the main current (winding *b*), whereas the other (3) is slightly compounded by this same current (winding *c*).

Under these conditions, the decompounded exciter (2) produces a voltage the value and direction of which vary essentially with the intensity of the main current, while the compound exciter (3) supplies a practically constant voltage. As a result of this arrangment :

a) When the intensity of the main current reaches an average value, the currents flowing through the separate excitation winding (*a*) and the opposing winding (*b*) of the anticompound exciter (2) balance one another.

b) When, starting from its mean value, the intensity of the main current decreases, the influence of the current in the separate excitation winding (*a*) progressively exceeds the principal current in the opposing winding (*b*). The anticompound exciter (2) supplies an increasing voltage in absolute value, and of the same sign as the constant voltage supplied by the compound exciter (3) to which it is added.

c) When contrariwise, starting from its average value, the intensity of the main current increases, the opposite occurs : the influence of the opposing winding (*b*) becomes progressively the more important; the anticompound exciter (2) supplies a voltage still increasing in absolute value, but of contrary sign to that of the constant voltage of the compound exciter (3) from which it is then deducted.

The resulting voltage at the terminals of the main generator, so obtained, varies with the intensity of the current delivered, according to a practically hyperbolic law.

So designed, this special excitation method enables the full power of the diesel to be used over large limits, which explains the name of « Vollastschaltung » under which the A. E. G. presents this design.

In recent so-called « with divided poles » applications, the same company (A. E. G. in Germany and G. E. C. O. in America) apply the principle described above, according to one or other of the two variants :

a) exciter with divided poles and main generator of usual type;

b) single exciter and main generator with divided poles.

This system will be applied under form *a* or *b* to three fast triple railcars of the Belgian National Railways Company.

[656. 222.1]

Note on Train Speeds,

by Lionel WIENER,
Professor at the University of Brussels.

PART II *(Continued)*. [1]

Train speeds and services in different countries.

IX. — SWITZERLAND.

SUMMARY.

CHAPTER XXXVI. — The railway system.

1. General.
   Lines across the Jura range of mountains.
   Tunnels between the Lakes of Lucerne and of Constance.
   Transalpine tunnels.
2. Metre-gauge systems.
3. Alternative lines.
4. Swiss Federal and Company Railways.
   Frontier line sections.
5. Track- and loading gauges.
6. Tariff mileages.

CHAPTER XXXVII. — The trains.

1. General.
2. Restaurant-, Pullman- and Sleeping-car services.
   International Sleeping-Car, *Mitropa*, and *Swiss Restaurant-Car* Companies.
   Services on metre-gauge lines.
3. Rolling stock used in international services.

CHAPTER XXXVIII. — The speeds.

1. General. — Secondary centres.
2. Electric traction.
3. Railcars.
4. Interesting runs.
5. Conclusions.

APPENDIX.

6. Rack railways.
7. Cable railways.
8. Lake steamship services.

CHAPTER XXXVI.

The railway system.

XXXVI-1. — **General.** — The location and organisation of the Swiss railways has been influenced by two factors : the political situation and the mountainous character of the country. Indeed, the passes through the great mountain ranges are limited in number, and have thereby forced the traffic into definite channels; on the other hand, the railways themselves have affected the economic development of the country, whose elements have

(1) Cf. *Bulletin of the Railway Congress*, October and November 1933; May, June and July 1934; February, March, April and May 1935.

so grouped themselves as to gain easy access to the lines whereas the less fortunate districts simply mark time — when they do not lose ground.

Apart from the Rhenish northern frontier, the others follow mountain ranges which have had to be tunnelled through. In many cases, approach lines have been difficult to build (fig. 207). To the west is the Jura, crossed by three international lines, while three Italian-Swiss lines, including one of metre gauge, cross the Alps in the South and East of the country.

Lines through the Jura. — The parallel chains of the Jura extend S. W. and N. E. from Geneva right up to the Rhine along the whole length of the frontier. As a result, the Aar and the succession of lakes of Joux, Neuchâtel and Bienne also lie in the same direction, as do the Geneva-Lausanne to Olten and Brugg and the Pontarlier to Basle railway lines. A few characteristics of other lines, built at right angles to them, climbing and tunneling through the Jura, are shown in the tables hereafter.

Line.	*Tunnel.*	*Length.*	
		Km.	Miles.
Zurich to Basle	Bözberg	2.526	1.57
Olten to Basle	Hauenstein II and I	2.495 8.134	1.56 5.05
Soleure to Moutier	Weissenstein	3.700	2.30
Lengnau to Moutier	Grenchenberg	8.565	5.32
Neuchâtel to La-Chaux-de-Fonds	Les Loges	3.259	2.03
Vallorbe to Frasne	Le Mont d'Or	6.099	3.79

Fig. 207. — Location of the largest Swiss tunnels.

The Hauenstein tunnels. — The original Hauenstein tunnel having been driven at too high a level with heavy-gradient approaches, another one has been bored lower down with longer and easier accesses, thus saving considerable work-

ing costs. The latter line only has been electrified.

The GRENCHENBERG TUNNEL is on a by-pass line whose construction formed part of a series of improvements undertaken so as to ameliorate the Simplon's approaches.

Similar work was undertaken in the case of the MONT D'OR TUNNEL, between Frasne and Vallorbe, which will be dealt with later.

As the mountains between the lakes of Lucerne and Constance are at right angles to the Jura, the rivers and thalweg line run in a S. E.—N. W. direction. In this case, the perpendicular railways are the heavily graded ones which run through tunnels, such as the ALBIS on the line joining the Lake of Zug with the Lake of Zurich, and the important RICKEN and WASSERFLUH tunnels, on the Uznach-St. Gallen line between the Lakes of Zurich and of Constance. These heavy works were undertaken with the object of extending the old *Swiss Union Railway* across the Alps, over the Lukmanier or the Splügen passes right into Italy.

The RICKEN TUNNEL is on a continuous gradient, and its ventilation was never satisfactory. Some years ago, a goods train stalled in it and the noxious gases from the locomotive asphyxiated six of the staff and three permanent-way men. To avoid further accidents, the line was immediately electrified, beginning with the 8.603 m. (5.35 miles) of the tunnel itself.

The Alpine tunnels. — The gradients of the oldest of the Swiss transalpine railways, the SAINT GOTHARD (1), did not exceed 1 in 27. Moreveor, from the traffic point of view, its location was remarkable. The whole of the line, from Milan and Chiasso to Lucerne (as well as Basle or Zurich) runs, generally speaking, South and North, which admirably suits the organisation of important international trains.

But owing to the cost of construction having been so heavy, the building of the projected extensions to Lucerne and Zurich was postponed, and the *Swiss North Eastern* and *South Argovian* Railways used to reach these places.

In the meantime, traffic increased so rapidly that it became necessary not only to prepare the duplication of the main line, but also, as later in the case of the Simplon, to improve its approaches.

On 1st June 1897, the Lucerne extension, via Immensee and Kussnach, was opened to traffic at the same time as three cut-offs for the St. Gothard-German through traffic via Stuttgart :

Arth-Goldau to Zug, via Walwyl;
Zug to Zurich, via Thalwyl;
Eglisau to Schaffausen.

These improvements comprised the ALBIS 3 358-m. (11 017 ft.) tunnel and the Eglisau high-level bridge over the Rhine (60 m. = 197 ft.) above mean water level.

In addition to the SIMPLON LINE'S through services, its building greatly influenced all older transalpine rail-

(1) The original contract for building the line was signed between three Swiss Cantons on 3rd August 1853 and the definite one, delayed by the 1866 and 1870 wars, on 6th Dec. 1871 only. Subventions amounting to 28, 30 and 53 million (gold) francs were paid by Switzerland, Germany and Italy.

T

SWISS TUNNELS OVER 2

COMPANY.	Located between		TUNNEL (*).	Single (S) or double (D) track.	Leng
	N. or W. portal.	S. or E. portal.			Km.
Bern-Lötschberg	Brig (N.).	Iselle (S.).	Simplon II.	S	19.823
Do.	Do.	Do.	Simplon I (**).	S	19.803
S. F. R.	Göschenen (N.).	Airolo (S.).	Gothard.	D	14.998
Bern-Lötschberg	Kandersteg (N.).	Goppenstein (S.).	Lötschberg.	D	14.612
Swiss Federal Rys. . . .	Wattwil (N.).	Uznach (S.).	Ricken.	S	8.603
Bern-Lötschberg	Munster (W.).	Grenchen (E.).	Grenchenberg.	S	8.565
S. F. Rys.	Tecknau (N.).	Olten (S.).	Hauenstein II.	D	8.134
Jungfrau Bahn (metre g.) .	Eigergletscher (E.).	Jungfraujoch (W.)	Jungfrau.	S	7.113
S. F. Rys.	Les Longuevilles (W.).	Vallorbe (E.).	Mont d'Or (**).	D	6.099
Rhätische Bahn (metre g.) .	Preda (W.).	Spinas (E.).	Albula.	S	5.865
Solothurn-Munster Bahn . .	Oberdorf (S.).	Gänsbrunnen (N.)	Weissenstein.	S	3.700
Bodensee-Toggenburg Bahn .	Brunnadern (E.).	Lichtensteig (W.).	Wasserfluh.	S	3.557
S. F. Rys.	Sihlbrugg (E.).	Baar (W.).	Albis.	S	3.359
S. F. Rys.	Hauts Geneveys (E.).	Convers (W.).	Les Loges.	S	3.259
S. F. Rys.	Courgenay (N.).	St. Ursanne (S.).	La Croix.	S	2.966
S. F. Rys.	Schinznachdorf (E.).	Effingen (W.).	Bözberg.	D	2.526
S. F. Rys.	Laufelfingen (N.).	Olten (S.).	Hauenstein I.	D	2.495
Montreux-Oberland (metre g.) .	Les Avants (W.).	Allières (E.).	Jaman.	S	2.424
Rhätische Bahn (metre g.) .	Ardez (E.).	Fetan (W.).	Tasna.	S	2.350
S. F. Rys.	Lucerne (W.).	Meggen (E.).	Musegg.	S	2.107
S. F. Rys.	Letten (N.).	Stadelhofen (S.).	Zürichberg.	S	2.093
S. F. Rys.	St. Ursanne (N.).	Glovelier (S.).	Glovelier.	S	2.010

The total length of the 324 Swiss tunnels is 281 628 m. (175 miles), 82 026 m. (50.96 m

(*) For comparison, the characteristics of a few other long European tunnels are quoted hereafter :

Apennine
Mt-Cenis . . . . 12.849 km. (7.96 miles) — alt. + 1 295 m. (4 249 feet).
Arlberg . . . . 10.240 km. (6.34 miles) — alt. + 1 310 m. (4 298 feet).
Tauern . . . . . 8.550 km. (5.31 miles) — alt. + 1 225 m. (4 019 feet).

ways (1), owing to the necessity of regulating traffic amongst its competitors.

The up and down tunnels, respectively 19 803 and 19 825 m. (12.305 and 12.319 miles) long (2) were opened to traffic on the 1st June 1906 and the 7th January 1922. This line differs from the other transalpine ones in the following respect : whereas the Italian section runs roughly South and North, the Swiss portion first runs East and West. In order to make full use of the possibilities of

(1) To aid in the financing of this undertaking, subsidies to the extent of some twenty million francs were granted. This sum was made up of 4 500 000 francs subscribed by the Swiss Confederation, 4 250 000 by the Cantons, and 4 000 000 lire by Italy. The latter country, in addition, pledged itself to build at its own expense several very costly access lines.

(2) 9.073 km. (5.636 miles) are in Switzerland and 10.752 km. (6.650 miles) in Italy.

4 MILES) IN LENGTH.

	Altitude.					Gradients.	
North or West.		Intermediate.		South or East.		Rising.	Falling.
res.	Feet.	Metres.	Feet.	Metres.	Feet.	1 in	1 in
..	...	...	...	...	...	...	...
386	2 250	(705)	(2 313)	634	2 080	500	142
109	3 638	(1 155)	(3 789)	1 144	3 753	172	500
120	3 675	(1 243)	(4 078)	1 219	4 000	142	263
622	2 041	...	...	487	1 598	...	63
535	1 755	(545)	(1 789)	484	1 588	400	77
148	1 470	442	1 450	406	1 332	667	133
234	7 329	...	...	3 457	11 342	Max. 40	...
811	2 660	...	...	900	2 953	92-77	...
792	5 879	1 823	5 981	1 818	5 964	100	500
359	2 162	...	...	722	2 369	56	...
557	2 156	...	...	620	2 034	...	96
517	1 696	...	...	446	1 463	...	...
994	3 261	1 052	3 451	1 050	3 445	40	667
521	1 709	(523)	(1 716)	512	1 680	1 000	182
444	1 457	...	...	464	1 522	125	...
992	1 942	...	...	496	1 627	...	38
991	3 579	(1 114)	(3 655)	1 113	3 652	434	400
384	4 541	(1 385)	(4 544)	1 344	4 410	...	50
442	1 450	444	1 457	440	1 443	333	333
310	1 345	415	1 362	414	1 358	333	500
116	1 693	523	1 716	522	1 713	196	1 000

metre-gauge lines.

(**) International tunnels :
10 718.79 m. (6.66 miles) of the Simplon tunnel are located in Italian territory and 9 084.21 m. (5.25 miles) in Switzerland.
989 m. (0.61 mile) of the Mont d'Or tunnel are in Switzerland, and 5 108 m. (3.18 miles) in France.

the Simplon route, it was therefore necessary to give careful attention to its approaches; with this object in view, considerable expenditure has had to be incurred and a number of international agreements for regulating traffic, have had to be entered into. It became necessary to improve the routes to Berne and beyond, as far as Basle, and to shorten the Paris route as well.

In order to give the Canton of Berne the outlet into Italy, for which it had long clamoured (1), the *Bernese Alps (B. L. S.)* (2) *Company* built the remarkable Lötschberg Railway. This was but a first stage introducing a new factor :

(1) Projected route via the Simmenthal and the Wildstrübel tunnel to the Valais; alternative route via the Stockhorn, from Berne to Zweisimmen; the Grimsel and Gemmi line.
(2) *B. L. S.* = *Bern-Lötschberg-Simplon.*

the participation of the French *Est Railway* in the international traffic thereby created.

Diplomatic negociations to regulate the Franco-Swiss traffic therefore had to take the interests of two French Companies — the *Paris-Lyons-Mediterranean*, and the *Est Railways* — into account. Then too, the *Lötschberg* line was in direct competition with certain lines of the *Swiss Federal Rys.* This is why interminable discussions dealt with such seemingly diverse subjects as the Frasne-Vallorbe, and the Moutier-Granges cut-offs, and the rates of the St. Gothard and Brenner lines.

Fig. 208. — Principal Swiss railways across the Alps, and access lines to the Lötschberg and Simplon routes.

GR = Grenchenberg. — BN = Berne-Neuchâtel direct. — BLS = Bern-Lötschberg-Simplon.
GB = Gürbetal Bahn. — TB = Thunersee Bahn.

The Federal Council intervened and the *Swiss Federal Rys.*' opposition to the building, by the *Bernese Alps Co. (B. L. S.)*, of the Moutier-Granges (Lengnau) section, was withdrawn. This latter Company therefore owns 44 % of the total length of the Brig and Basle line, including the most difficult parts, as it had built the Lötschberg and Grenchenberg tunnels and their approaches. As

a preliminary step, the *Bernese Alps Co.* had leased or purchased several other railways (1), the entire line being made up as follows :

	S. F. R.		*B. L. S.*		
	Km.	Miles.	Km.	Miles.	
Brig-Frutigen	...	...	60.9	37.8	Owned by the *B. L. S. Co.*
Frutigen-Spiez	...	...	13.5	8.4	Purchased.
Spiez-Thun	...	...	11.2	7.0	*Thunerseebahn*, purchased.
Thun-Berne-Lengnau (2).	75 1	46.7	...	...	*Swiss Federal Railways.*
Lengnau-Moutier . . .	...	...	12.9	8.0	Owned by the *B. L. S. Co.*
Moutier-Basle (3) . . .	49.9	31.0	. .	...	*Swiss Federal Railways.*
Total. .	125.0	77.7	106.9	65.0	

As far as the Basle-Milan traffic is concerned, and in spite of the building of the Moutier-Granges cut-off, the Lötschberg is slightly longer than the Saint Gothard route. On the other hand, since the opening of the Frasne-Vallorbe short cut, the *Paris-Lyons-Mediterranean*'s line between Paris and Brig, is somewhat shorter than the *Est*'s route, via Basle (fig. 208).

Comparative distances are as stated hereunder :

TABLE 202.

LENGTH OF LINES COMPETING FOR ITALIAN TRAFFIC.

LINE.	Route followed.	Distance.	
		Km.	*Miles.*
Basle-Milan	Lötschberg line	398	247.3
Do.	St.-Gothard line	372	231.2
Paris-Brig	*Est* and Lötschberg	698	433.7
Do.	*P. L. M.* and Mont d'Or route .	655	407.0
Paris-Milan	*Est* and Lötschberg	864	536.9
Do.	Basle and St.-Gothard route . .	898	558.0
Do.	*P. L. M.* and Simplon	821	510.1
Do.	Mount-Cenis line	921	572.3

Like the standard, the metre-gauge lines have to overcome very great constructional difficulties in these mountainous districts where, often by means of loops and long tunnels one would hardly expect to find on such railways,

(1) The *Bernese Alps Company (B. L. S.)* (fig. 208) also purchased the *Gürbetalbahn* which gave it access to Berne (via Belp).

It operates the *Spiez-Erlenbach* (10.5 km. = 6.5 miles) and the *Erlenbach-Zweisimmen Railways* (23.6 km. = 14.7 miles), the Lakes of Thun and Brienz steamship services and the Beatenberg Rope Ry.

(2) I.e. 30 km. (18.6 miles) from Thun to Berne, and 45 km. (28 miles) from Berne to Lengnau.

(3) From Moutier to Delle *(Swiss Federal Railways)*, the distance is 51 km. (31.7 miles).

they climb up to a considerable height above sea level.

Train services on lines with artificial adhesion are dealt with in an appendix (XXXVIII-6) and only simple-adhesion railways are considered here.

XXXVI-2. — **Swiss metre-gauge railways.** — If an imaginary line were drawn parallel to the basic S. W.-N. E. direction of the great railways, running through Montreux, Thun, Lucerne and Sargans, nearly all the standard-gauge lines would lie to the North, while only the 500 km. (310 miles) of the Simplon, Lötschberg and St. Gothard, together with some thousand km. (620 miles) of metre-gauge lines would be found South of it (fig. 209). These latter would notably include the following lines :

	Km	*Miles.*
Greierzer-Bahn	50	31.1
Montreux-Berner Oberland Bahn	105	65.3
Aigle-Sépey-Diablerets	23	14.3
Martigny-Orsières	21	13.0
Berner Oberland Bahnen	23	14.3
Brünigbahn (*S. F. R.*)	57	35.4
Stansstad-Engelberg	22	13.7
Viège-Zermatt	44	27.3
Furka-Oberalp	97	60.3

	Km.	*Miles.*
Rhätische Bahn	276	171.5
Coire-Arosa	26	16.2
Bernina Ry.	61	37.9
Biasca-Acquarossa	13	8.1
Bellinzona-Mesocco	31	19.3
Locarno-Bignasco-Camedo	46	28.6
Lugano, various	29	18.0

The Alpine metre-gauge railways include an unbroken system of 544 km. (338 miles) of lines, belonging to the *Rhätische Bahn*, the *Furka-Oberalp* and the *Viège-Zermatt* Companies. The proposed connection from Gletsch to Meiringen, via the Grimmsel, would link up the *Federal Railways'* metre-gauge with the *Brünigbahn*. These are not, properly speaking, secondary lines as they by themselves serve important districts and run through trains over considerable distances.

TABLE 203.

MAXIMUM GRADIENTS OF A FEW SIMPLE-ADHESION MOUNTAIN LINES.

RAILWAY.	Gauge.	Steepest gradient.	Vehicle.	Weight, tons.		Speed.	
				Metric	*Engl.*	Km. h.	*M p.h.*
Railcars.							
Val de Travers Ry.	4 ft. 8 1/2 in.	1 in 55	Railcar.	67	65.9	70	43.5
Electric traction.							
Bernina	Metre.	1 in 14	Bogie motor coach.	45	44.3	45	28.0
Schwyz-Brunnen	Do.	1 in 14	4-wheeled motor coach.	25	24.6	30	18.6
Montreux-Berner Oberland	Do.	1 in 15	Bogie motor coach.	130	127.9	45	28.0
Aigle-Ollon-Monthey	Do.	1 in 15.5	Do.	30	29.5	45	28.0
Lugano-Tesserete	Do.	1 in 15.5	Do.	40	39.4	40	24.9
Coire-Arosa	Do.	1 in 17	Do.	70	68.9	45	28.0
Nyon-La Cure	Do.	1 in 17	Do.	62	61.0	45	28.0

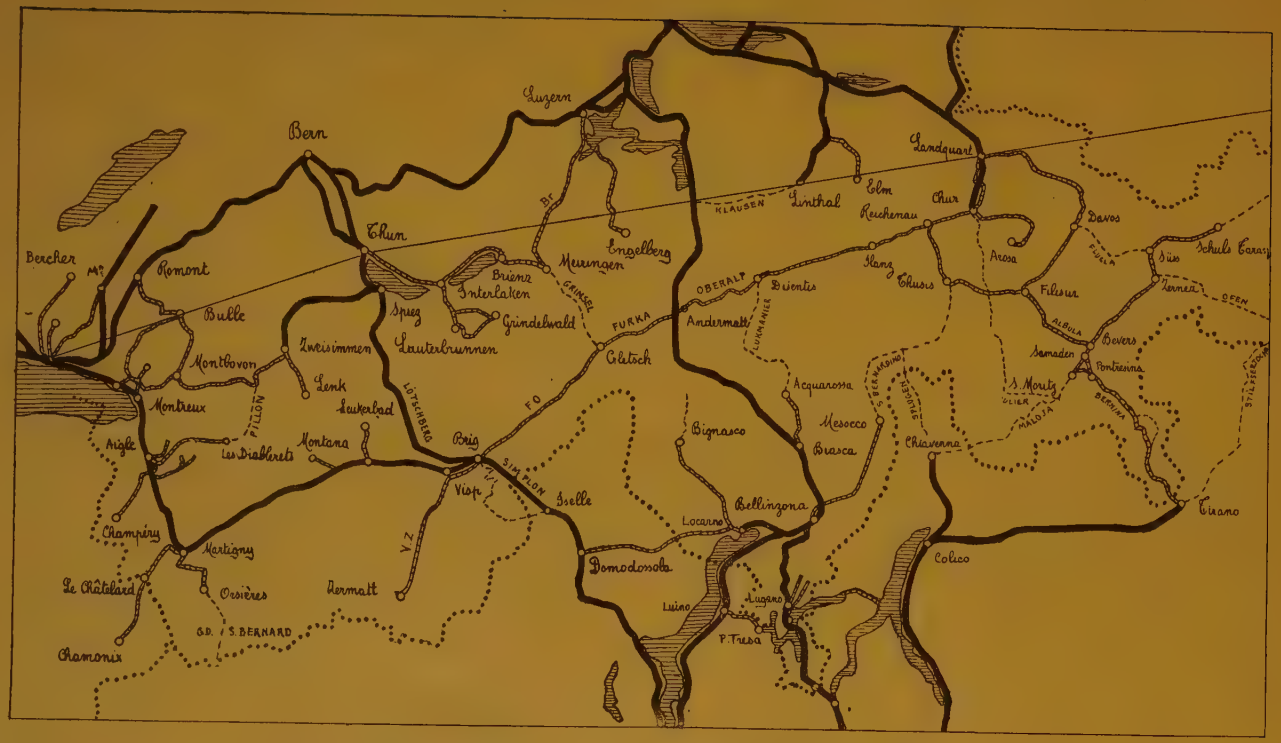


Fig. 209. — Southern Switzerland metre-gauge railway system.
The standard-gauge railways are shown in heavy lines.
Roads over the Alpine passes are shown in thin broken lines.

When maximum gradients were reached, steam locomotives were superseded by electric traction. Sometimes (as on the *Greierzer Bahn)* steeper gradients have been allowed on the mountain sections than in the valleys (1 in 20 instead of 1 in 33) (1). On important railways such as the *Rhätische Bahn,* the 1 in 28.5 gradients of the Coire-Saint-Moritz line (reduced to 1 in 33 in the tunnels) reach as much as 1 in 22 between Landquart and Davos (2).

1 in 14 gradients are to be met with on the *Bernina Railway* and even this is not the maximum light railways admit (3), and tramways are occasionally steeper still, Lugano having 1 in 11.8 gradients, Spiez, 1 in 11.5 and Lausanne as much as 1 in 8. In spite of this, some railways have had to resort to racks, sometimes over long stretches of line.

The maximum speed allowed over the *Bernina Ry.*'s 1 in 14 gradients is 18 km. (11.2 miles) an hour. On the *Rhätische Bahn,* the locomotives haul 200 tons at 50 km. (31 miles) an hour on the level, and at 32 km. (20 miles) an hour up 1 in 28.5 gradients.

Reverses are to be met with, but they usually appear under the guise of intermediate termini.

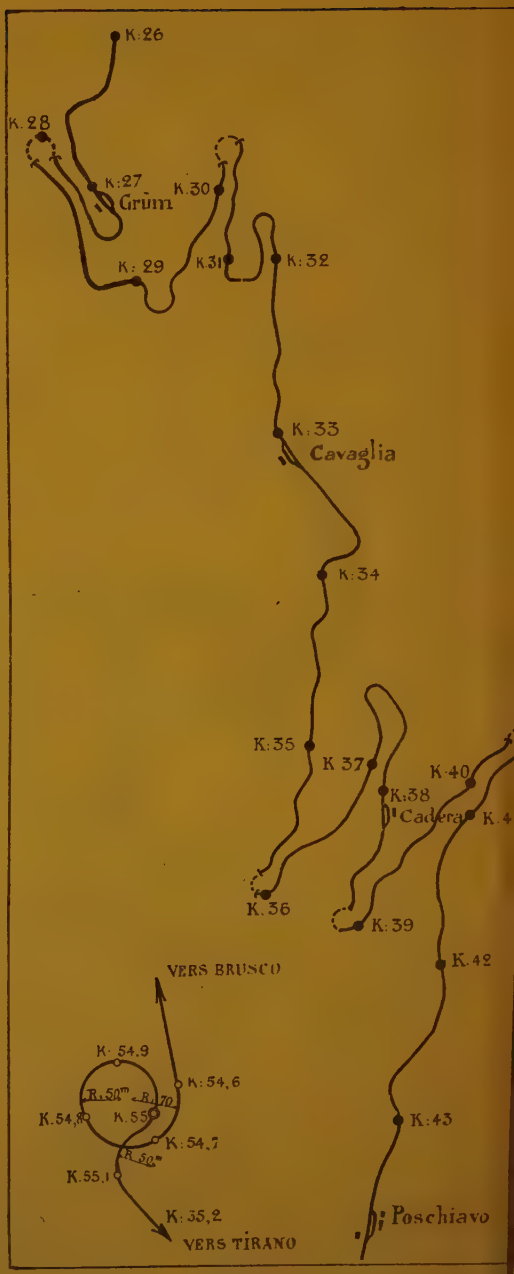


Fig. 210. — Loops of the *Bernina Railway*.

(1) Minimum radius of curves : 100 and 50 m. (5 and 2 1/2 chains) respectively.

(2) The maximum gauge widening is 24 mm. (15/16 inches), and the maximum superelevation on curves of 100 m. (5 chains) radius is 0.125 m. (1/2 inch).

(3) The Fayet-Chamonix Railway has 1 in 11 gradients, the Dermulo-Mendelpass Ry. in Southern Tyrol 1 in 12.5 inclines. Actually, gradients as steep as 1 in 10.5 are to be found at Gmunden (Austria) and on the Italian Bisuchi-Vigglu line.

TABLE 204.

Reverses.	Railway.	Section.
Meiringen	Brünigbahn.	Lucerne to Brienz.
Before Menaggio . . .	Ferr. e Nav.	Menaggio to Porlezza.
Chambrelien	S. F. Rys.	Neuchâtel-La Chaux-de-Fonds.
Grindelwald	Berner Oberland.	Lauterbrunnen-Grindelwald.
Vallorbe	S. F. Rys.	Now converted into a through station.

Following the example of the Saint Gothard and Lötschberg railways' double loops, those on the *Rhätische Bahn* (Rhaetian Railway) (1), the *Furka-Oberalp*, and the many loops of the *Bernina* Railway (fig. 210) have enabled these railways to rise considerably in a short distance as the crow flies.

The BERNINA RAILWAY joins Upper Engadine with the Pô valley. It was possible to avoid using a rack and to build the line as a simple-adhesion one, with continuous 1 in 14 gradients (2). Along a distance of 22 km. (13.7 miles) as the crow flies, on the southern approach, a difference in level of 1 827 m. (5 994 ft.) is negotiated along 39 km. (24.2 miles) of route mileage.

The Bernina Hospice, the highest point on the line, is 2 256 m. (7 402 ft) above datum. This is one of the highest points reached on Swiss simple-adhesion railways (fig. 211).

Long tunnels occur on all these metre-gauge lines, with the exception of the latter one. The *M. B. O.*, for instance, passes two summits (3) at 1 115 and 1 275 m. (3 658 and 4 183 feet) above datum, the first of them in the Jor tunnel, which is 2 424 m. (1.51 miles) long.

There are 38 tunnels on the *Rhätische Bahn*'s main line, totalling (the Albula tunnel excluded), 10 161 m. (6.3 miles). Including this tunnel, no less than 27 % of the entire distance is underground, and 43 %, on curves.

The *Furka-Oberalp* and the *Rhätische Bahn*'s spiral tunnels make up considerable differences in level. For purposes of comparison, table 206 quotes similar data for the Swiss spiral tunnels on standard-gauge lines.

(1) *Rhätische Bahn.* — Between Filisur and Bergun, artificial development 1 200 m. (0.75 mile) long with a spiral tunnel 698 m. (0.434 mile) long occurs.

Between Bergun and the northern portal of the Albula tunnel the distance is 6.5 km. (4.0 miles), in which 5.5 km. (3.4 miles) of artificial development make it possible to climb 416 m. (1 300 feet).

The first group of loops includes two helicoidal tunnels, and the second, on a curve of 120 m. (6 chains) radius, three tunnels measuring 622, 677, and 535 m. (0.386, 0.421 and 0.332 mile) respectively.

(2) Between Poschiavo and the Hospice, there are 18 km. (11.2 miles) of 1 in 14 gradients, continuous save at the halts. There are 28 km. (17.4 miles) of 1 in 20 to 1 in 14 gradients, i.e. 46 % of the total length. The radius of curves is 50 m. (2 1/2 chains), sometimes 45 m. (2 1/4 chains), and exceptionally 40 m. (2 chains). The curves represent 42 % of the total length, and 30 % of them have a radius of less than 200 m. (10 chains).

(3) The height gained is as follows :

Montreux	0 km.	+	395 m. (1 296 feet).
Jor tunnel	15 km. (9.3 miles).	+	1 115-1 113 m. (3 658-3 652 feet).
Montbovon	22 km. (13.7 miles).	+	797 m. (2 615 feet).
Summit	...	+	1 275 m. (3 658 feet).
Zweisimmen . . .	62.5 km. (38.8 miles).	+	941 m. (3 087 feet).

TABLE 205.

MAXIMUM HEIGHT ABOVE SEA LEVEL, REACHED BY SOME OF THE SWISS LINES.

Origin.			Highest point on the run.						Railway Company.
Place.	Altitude.		Station.	Altitude.		Distance.		Difference in altitude.		
	Metres.	*Feet.*		Metres	*Feet.*	Km.	*Miles.*	Metres.	*Feet.*	
Simple-adhesion metre-gauge lines.										
Tirano	429	1 407	Bernina Hospice	2 256	7 401	39	24.2	1 827	5 994	Bernina Railway.
Thusis	700	2 297	Spinas (tunnel)	1 822	5 978	48	29.8	1 122	3 681	Rhätische Bahn.
Montreux	398	1 306	Allières	1 009	3 311	17	10.6	611	2 005	Montreux-Berner Oberland.
Zweisimmen	945	3 100	Saanenmöser	1 272	4 074	9	5.6	297	974	Do.
Schuls	1 290	4 232	Bevers	1 713	6 020	49	30.4	423	1 388	Rhätische Bahn.
Disentis	1 133	3 717	Coire	587	5 508	59	36.7	546	1 791	Do.
Mixed lines.										
Viège	651	2 136	Zermatt	1 608	5 276	35	21.7	957	3 140	Viège-Zermatt Ry.
Martigny	467	1 532	Finhaut	1 227	3 960	15	9.3	740	2 428	Martigny-Châtelard Ry.
Brig	672	2 205	Furka	2 164	7 100	52	32.3	1 492	4 895	Furka-Oberalp Bahn.
			Oberalpsee							
Disentis	1 133	3 717	Oberalpass	2 033	6 670	21	13.0	900	2 953	Do.
				2 048	6 719	...	...	...	...	
Pure rack railways.										
Scheidegg	2 064	6 771	Jungfraujoch	3 457	11 341	9.4	5 84	1 393	4 570	Jungfraubahn.
Zermatt	1 608	5 276	Gornergrat	3 093	10 148	9.3	5.8	1 485	4 872	Gornergrat Bahn.
Brienz	568	1 864	Rothorn Kulm.	2 252	7 389	7.6	4 7	1 684	5 525	Brienz-Rothorn.
Alpnachstad	437	1 434	Pilatus Kulm.	2 070	6 792	4.6	2.8	1 633	5 358	Pilatus-Bahn.
Lauterbrunnen	798	2 618	Scheidegg	2 064	6 772	10.5	6.5	1 266	4 154	Wengernalp Bahn.

TABLE 206.

ALTITUDE GAINED BY MEANS OF SWISS HELICOIDAL TUNNELS (LOOPS).

Railway.	TUNNEL.							LOOP.					
	Length.		Gradient.	Altitudes.				Radius of curve.		Difference in height.		Length.	
	Km.	*Miles.*		Metres.	*Feet.*	Metres.	*Feet.*	Metres.	*Chains.*	Metres	*Feet.*	Km.	*Miles.*
Metre-gauge lines.													
FURKA-OBERALP.													
Grengiols	0.593	0.368	1 in 11	906	2 972	956	3 136	100	5	53.4	175	0.594	0.37
Gletsch	0.578	0 359	1 in 12.5 and 1 in 9 for rack section.	1 673	5 489	1 721	5 646	80	4	43.4	142	0.519	0.32
RHÄTISCHE BAHN.													
Greifenstein	0.699	0.434	1 in 32	1 118	3 668	1 140	3 740	120	6	36.6	120	1.110	0 69
Rugnux	0.662	0.411	1 in 28.5-32	1 602	5 256	1 623	5 324	155 and 120	7 1/4 and 6	30.1	99	0.923	0.57
Toua	0 677	0.421	1 in 28.5-33	1 660	5 446	1 681	5 515	120 and 300	6 and 15	26.4	87	0.838	0.52
Zuondra	0.535	0.332	1 in 33	1 712	5 617	1 727	5 666	120	6	25.9	85	0.825	0.51
Standard-gauge lines.								Lower altitude.		Upper altitude.			
ST. GOTHARD.								Metres.	*Feet.*	Metres.	*Feet.*		
Pfaffensprung	1 476	0.915	1 in 38	771.2	2 530	805.1	2 641	772.5	2 534	882.1	2 894	49.6	163	2.075	1.29
Freggio	1.568	0.975	1 in 38	911.2	2 990	874.5	2 869	921.8	3 024	876.0	2 874	45.8	150	1.920	1.19
Prato	1.560	0.969	1 in 38	828.7	2 719	792.7	2 601	841.8	2 762	796.4	2 613	45 4	149	1.910	1.187
Piano	1.508	0.937	1 in 38	552.6	1 813	517.9	1 699	566.5	1 859	522.5	1 714	44.1	145	1.900	1.181
Travi	1.547	0.962	1 in 38	492.5	1 616	456.9	1 499	502.9	1 650	457.2	1 500	45.7	150	1.910	1.187

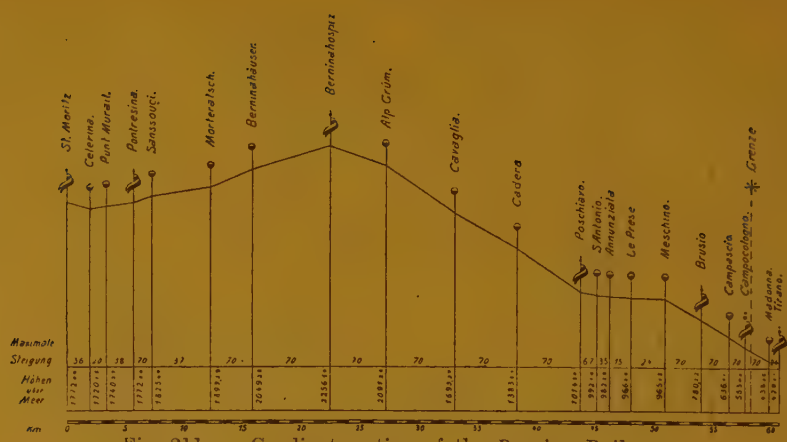


Fig. 211. — Gradient section of the *Bernina Railway*.

Note: Maximale Steigung = maximum gradient. — Höhen über Meer = heights above sea level.

XXXVI-3. — **Alternative lines.** — Since the amalgamation of the Swiss railways, there is but a single group of home-traffic alternative lines; it links up (Geneva), Lausanne and Basle, either via Bienne or via Berne (fig. 233).

As regards international traffic, the Lötschberg and Saint Gothard routes compete for the international Franco-Swiss traffic, such as the Brig and Bernese Oberland services. Similar transit competition exists between the French *Paris-Lyons and Mediterranean* and *Est* Railways, for their share in the transit traffic to and from the Near East, via Basle-Zurich-Buchs (and the Arlberg) or via Vallorbe-Lausanne (and the Simplon) routes, the *Swiss Federal Railways*, in the latter case, having an unequal share in both routes.

Relocated lines. — In many cases, old locations have been improved upon, through the construction of short cuts or the driving of lower level tunnels. It is, in fact, generally agreed, with Lommel, that a saving of 10 metres in altitude is equal to a shortening of 1 km. and the Swiss rating system of his time was based on this assumption.

Thus, between Lucerne and Arth-Goldau the St. Gothard Railway used to run via Rothkreuz. Since then, its length has been reduced from 44 to 28 km. (27.3 to 17.4 miles) through the building of the Immensee cut-off, which involved the boring of a 2 107 m. (1.30 miles) tunnel.

The Hauenstein tunnels. — Between Basle and Olten the 2 495 m. (1.55 miles) Hauenstein tunnel, lying at 592 m. (1 942 feet) above sea level, has been superseded by a lower level one 8 134 m. (5.05 miles) long (1) which is only 448 m. (1 470 feet) above datum; at the same time, the maximum gradients have been reduced from 1 in 38 to 1 in 133.

A similar instance occurs at Giovi, in the Apennines, where two lines have been electrified, while at the Hauenstein, only the newer one has been.

(1) The second Hauenstein tunnel was opened to traffic on the 8th January 1916. The distance from Olten to Sissach, is 21 098 m. (13.05 miles) by the new tunnel, and from Sissach to Basle 18 095 m. (11.20 miles).

TABLE 207.

A FEW ALTERNATIVE LINES.

RUN.	Via	Distance. Km.	Distance. *Miles*.	Best time.	Number of stops.	—
MAIN LINES.						
Basle to Milan	Lötschberg.	387(*)	240	7.45	...	S. F. Rys. and Berner Alpenbahn.
Do.	St.-Gothard.	372	231	6.55	...	S. F. Rys.
Lausanne-Basle	Berne.	206	128	4.47	...	S. F. Rys.
Do.	Bienne.	177	110	4.03	...	S. F. Rys. and Grenchenberg.
RELOCATED LINES.						
Bienne-Moutier (Basle).	Sonceboz.	40	25	...	. .	S. F. Rys.
Do.	Lengnau.	24	15	0.26	...	Berner Alpenbahn (B. L. S.)
Olten-Sissach (Basle) . .	Sommerau.	16	10	0.37	5	Hauenstein I tunnel.
Do. . .	Gelterkinden.	13	8	0 19	...	Hauenstein II tunnel.
Lucerne-Arth Goldau . .	Zug.	44	27	0.42	...	First St. Gothard line.
Do. . .	Immensee. .	28	17	0.26	...	New St. Gothard line.
STANDARD OR METRE-GAUGE LINES.						
Lucerne-Interlaken . . .	Lengnau-Berne (**)	154	97	3.15	...	S. F. Rys. and Berner Alpenbahn.
Do. . . .	Meiringen.	74	46	2.26	...	Brünigbahn (S. F. Rys.).
Lucerne-Berne	Lengnau.	97	60	1.44	...	S. F. Rys.
Do.	Meiringen-Interlaken.	134	83	4.59	...	S. F. Rys. and Brünigbahn.
Viège-Brig	Standard gauge.	9	6	0.08	...	S. F. Rys.
Do.	Narrow gauge.	9	6	0 15	...	Viège-Zermatt Ry.
Landquart-Coire	Standard gauge.	14	9	0.11	...	S. F. Rys.
Do.	Narrow gauge.	14	9	0.27	5	Rhätische Bahn.
METRE-GAUGE LINES.						
Coire-Filisur	Landquart-Davos.	83	52	2 50	...	Rhätische Bahn.
Do.	Thusis	51	32	1.25	...	Do.

(*) This distance is made up as follows :
Basle to Bienne . . . 74 km. (45.9 miles), formerly 90 km. (56 miles).
Bienne to Berne . . . 34 km. (21.1 miles).
Berne-Domodossola . . 156 km. (96.9 miles).
Domodossola-Milan . . 123 km. (70.4 miles).

(**) Including the 16 km. (10 miles) of the Berne-Gümligen section, which is run over twice.

The MOUTIER-GRANGES CUT-OFF. — To improve the Lötschberg's approaches, two sections lying far apart, have had to be built, each with a long tunnel.

Between Berne and Basle, the obsolete 40-km. (25 miles) stretch from Bienne through Sonceboz to Moutier (fig. 212*a*) has been superseded by a short line which includes a new 13.8 km. (8.1 miles) railway between Lengnau (11th km. = 6.8 miles, of the Bienne Olten section) and Moutier, crossing the Grenchenberg by a low level 8 560-m. (5.32 miles) tunnel (1).

The through traffic between Berne and Basle, between (Lausanne) Bienne and

(1) This line was inaugurated on the 1st October 1915. A little further North, another line connecting Moutier with Soleure, crosses the same mountain range by means of the Weissenstein 3 700-m. (2.3 miles) tunnel.

Basle and that from (Lausanne or Berne) Bienne-Délémont-Delle towards the French *Est* system runs over this shortened route; this is why the *Est Ry. Co.* shared in the construction costs by means of a subsidy of 10 000 000 (gold) frs.

Traffic apportionment between the new line and that of the *Swiss Federal Rys.* was the subject of lengthy discussions. As an outcome of them, it was decided that the latter Administration should operate the new line at cost price plus overhead charges on behalf of the *B.L.S.*, and surrender 70 % of the goods traffic for which the new line is the shorter in spite of its being virtually lengthened, for tariff purposes, by 10 km. (6.2 miles). It was thus able to secure transit traffic, in lesser proportion, however, than its importance seems to call for.

This route is only electrified as far as Delle.

The FRASNE-VALLORBE railway (1) is another chord line built in connection with the Simplon's approaches, which required that the route from Lausanne to Dijon be also shortened by an improvement of its location between Vallorbe and Mouchard, or, failing this, between Vallorbe and Frasne, thereby saving 18 km. (11.2 miles) in length and 117 m. (384 feet) in height, as compared with the former detour through Pontarlier. This entailed the boring of a tunnel through the Mont d'Or, 6 104 m. (3.8 miles) in length. It was entirely financed by the *Paris-Lyons-Mediterranean Ry.*, Switzerland having granted the *Jura-Simplon*, in 1902, on behalf of the above French Company, the concession for a 1 425 m. (0.88 mile) frontier section, besides inciting it to improve its own line. The Canton of Vaud awarded a subsidy of 2 000 000 (gold) frs. towards expenses for the driving of the tunnel and, at the same time, for doing away with reversing at Vallorbe (2).

All this reduced the distance from Paris *P.L.M.* to Brig, to 698 km. (433.7 miles), while it is 696 km. (432.5 miles) by the *Est*'s system.

METRE-GAUGE LINES. — Actually neither the *Brünig* nor the *Furka-Oberalp* lines compete with the *Swiss Federal Railways*, as the former are chiefly tourist lines and the latter main lines. So far, neither of the two metre-gauge railways has been electrified.

The *Furka-Oberalp* line connects Zermatt with Upper and Lower Engadine. It takes 8 h. 50 m. to travel over its 226 km. (140.4 miles) as far as St. Moritz, while it only takes 5 h. 42 m. over the 508 km. (340.5 miles) standard-gauge route from Brig to St. Moritz (3) via Berne, Lucerne and Thalwil.

---

(1) The distance from Frasne to Pontarlier is 17 km. (10.56 miles) and 43 km. (26.7 miles) to Vallorbe, while the short cut is only 25 km. (15.5 miles) long.

(2) The Mont d'Or tunnel was opened to traffic on the 16th May 1915.

Geneva wanted a more direct line and it was proposed to combine this with a new line to Italy through the Mont Blanc or the Petit Saint-Bernard.

An essentially French line, connecting Saint-Amour and Bellegarde and crossing the Jura and Ain, was also suggested, and a new line from Dijon to Geneva via Lons-le-Saulnier and the Faucille was also proposed. Its maximum altitude would not have exceeded 559 m. (1 834 feet) above datum with 1 in 100 gradients but this entailed the driving of 35 km. (21.7 miles) of tunnels and the routing of traffic along both shores of the Lake of Geneva. In spite of this, this proposal is still being investigated.

In the meantime, according to the agreements previously come to, the Confederation bought from the *P. L. M. Ry.* (who continues to operate it), the Geneva-La Plaine line and built a new 15 km. (9.3 miles) connection between the Geneva stations.

(3) As far as Coire, there is only 371 km. (230.5 miles), and 157 (97.6 miles) by the metre-gauge lines (*F. O.* and *Rh.*).

XXXVI-4. — The Swiss Federal Railways and the private Companies. — The *Swiss Federal Railway* system, which has a certain degree of independence, was formed by the purchase, between 1901 and 1909, of the five principal Swiss railway systems, which then included 2 647 km. (1 683.9 miles) of line (1). Even so, the *Swiss Federal Rys.* only operate about half the Swiss lines, including 2 943 km. (1 828.8 miles) of standard and 74 km. (45.9 miles) of metre-gauge lines (2) besides a few leased railways (3).

The rest is apportioned amongst 211 companies, some of which, through the amalgamation of several lines, operate systems of some importance.

Among the standard-gauge railways, the *Bernese Alps Company (Bern-Lötschberg-Simplon* or *B.L.S.)* owns 117 km. (72.7 miles) of railways, besides operating 111 km. (69.0 miles) of additional lines, amongst which :

Berne-Schwarzenburg	21 km.	(13.0 miles).
Erlenbach-Zweisimmen	24 km.	(14.9 miles).
Spiez-Erlenbach	24 km.	(14.9 miles).
Gurbetalbahn	12 km.	(7.5 miles).

In the same region, the *Berne-Neuchâtel Direct* (43 km. = 26.7 miles) is a still independent section, inserted in the great international Paris *P.L.M.*-Berne-Berner Oberland line. Together with the *Bernese Alps Company* (which operates it) this is the only Company running express trains, the other railways being above all regional in character (4).

The group of lines belonging to the *Emmentalbahn* (fig. 212*a*) prolong the *Lötschberg Railway* from Thun to Moutier. This railway owns 43 km. (26.7 miles) of line and operates another 56 km. (34.8 miles), the system being made up as follows :

The Emmentalbahn (Lengnau-Burgdorf-Soleure)	43 km.	(26.7 miles).
Soleure-Moutier (leased line) (5)	23 km.	(14.3 miles).
Berthoud-Thun (leased line)	33 km.	(20.5 miles).

(1) As follows :

S. C. B.	Central Suisse Ry.	401 km.	(249.2 miles).	In 1901.
N. O. B.	Nord-Est Ry.	766 km.	(476.0 miles).	— 1901.
V. S. B.	Union Suisse Ry.	269 km.	(167.2 miles).	— 1901.
J. S.	Jura-Simplon Ry.	938 km.	(582.9 miles).	— 1903.
G. B.	St. Gothard Ry.	273 km.	(169.4 miles).	— 1909.

The dates given are those when the line was taken over, the contract for so doing having in some cases been signed at a much later date.

(2) The *Brünig* Railway, with both adhesion and rack sections.

(3) As follows :

Vevey-Chexbres Ry.	8 km.	(5 miles).
Bodensee-Toggenburg Bahn	67 km.	(41.6 miles).
Bulle-Romont Ry.	19 km.	(11.8 miles).
Nyon-Crassier Ry.	6 km.	(3.7 miles).
Wald-Rüti Ry.	7 km.	(4.35 miles).

(4) The most important are :

Fribourg-Morat-Anet	33 km.	(20.5 miles).	
Seetalbahn	55 km.	(34.2 miles).	(Lucerne) Emmenbrücke, Wildegg and branches.
Südostbahn	50 km.	(31.0 miles).	Arth-Goldau-Rapperswil and branches.
Tösstalbahn	40 km.	(24.9 miles).	Winterthur-Wald-Rüti.
Saignelégier-Glovelier	25 km.	(15.5 miles).	
Porrentruy-Bonfol	14 km.	(8.7 miles).	Leased railway.

The Saignelégier-La Chaux-de-Fonds line (27 km. = 16.8 of metre-gauge track) belongs to another company.

(5) This line includes the Weissenstein tunnel.

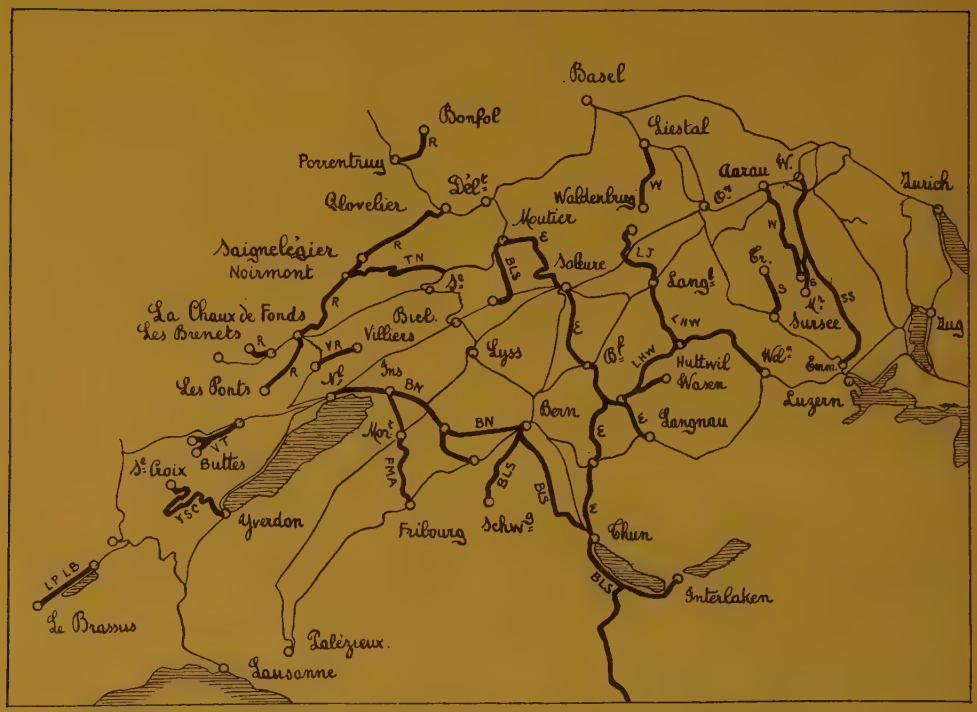


Fig. 212*a*. — Standard-gauge lines operated by Swiss private Companies in Western and Central Switzerland.

Legend :

BLS	Berne - Lötschberg - Simplon (System worked by the).	R	Regional Rys. (1).
BN	Berne-Neuchâtel Direct.	S	Sursee-Triengen.
E	Emmenthal Bahn (Group).	S	Schweiz, Seetalbahn (Emmenbrücke-Wildegg).
FMA	Fribourg-Morat-Anet (Ins-Murten-Fribourg).	TN	Tavannes-Tramelan-Noirmont.
LHW	Langenthal-Huttwil-Wolhusen.	VR	Val de Ruz.
LJ	Langenthal-Jura.	VT	Val de Travers.
LPLB	Le Pont-Le Brassus.	W	Waldenburgerbahn.
		YSC	Yverdon-Sainte-Croix.

By this route, the distance from Thun to Moutier is 84 km. (52.2 miles), the same as that of the old route via Berne, which the Moutier-Granges cut-off has since reduced to 64 km. (39.8 miles).

In addition to its own line, the *Langenthal-Huttwil Co.* (20 km. = 12.4 miles) operates the *Ramsei-Huttwil Railway* (25 km. = 15.5 miles), which brings its kilometrage up to 71 (44.1 miles).

(1) These are the following :
Brenets District Railway (Le Locle-Les Brenets).
Porrentruy-Bonfol.
Ponts-Sagne—La Chaux-de-Fonds.
Saignelégier—La Chaux-de-Fonds.
Saignelégier-Glovelier.

Fig. 212*b*. — Standard-gauge lines operated by private companies. — Eastern Switzerland.

Legend :

BT	Bodensee-Toggenburg Bahn.
M	Mittelthurgaubahn (Wil-Konstanz).
RH	Korschach-Heiden Ry.
S	Sihltalbahn (Zurich).
SSO	Schweizerische Südostbahn.
T	Tösstalbahn.
UB	Uerikon-Bauma Bahn.

The main line of the *Bodensee-Toggenburg Bahn (B.T.B.)*, operated by the *Swiss Federal Railways* with stock belonging to the *B.T.B.*, links up the Lakes of Constance and Zurich, from Romanshorn towards Rapperswil, via Saint-Gall and Wattwil (53 km. = 32.9 miles) with a 17-km. (10.6 miles) branch to Nesslau. Starting at an altitude of 400 m. (1 312 feet), it climbs to 800 m. (2 624 feet) at Degersheim (37th km. = 23rd mile), then descends to 617 m. (2 024 feet). The last 23 km. (14.3 miles) from Wattwil to Rapperswil, including the Ricken tunnel, belong to the *Swiss Federal Railways*.

The frontier sections. — The agreements made when building the Alps and Jura railways have led to very special operating conditions as a result of which three of the *Swiss Federal Rys.*' lines run into foreign territory.

Although the St. Gothard railway ends at Chiasso, the Pino—Luino (15 km. = 9.3 miles) branch belonging to the *Italian State* Railways is operated by the *Swiss Federal Rys.* In addition, the 10 719 m. (6.67 miles) of the Simplon tunnel, which lie in Italy, besides the 11 km. (6.83 miles) of railway extending it to Iselle, belong to the *Swiss Federal Rys.*, which operate them, as well as the adjacent 19 km. (11.8 miles) of the *Italian State Rys.*' Iselle-Domodossola section.

In the Jura, the *Swiss Federal Rys.* operate 3 km. (1.86 miles) of line between the frontier and Vallorbe, and 11 km. (6.83 miles) belonging to the *P.L.M.*, from Pontarlier to Verrières (towards Neuchâtel).

Against this, the *Swiss Federal Rys.*, do not operate any section of railway in the part of Switzerland that lies north of Basle-Town, the 4 km. (2.5 miles) linking them up with Alsace being operated by the *Alsace-Lorraine Rys.* and the 10 km. (6.2 miles) of the two junction lines with the Baden system, which formerly belonged to this Administration, now belonging to the *Reichsbahn.*

Owing to the layout of the frontier around Schaffhausen, the situation there is a peculiar one. The *Swiss Federal Rys.* own the entire Eglisau-Schaffhausen railway, including 8 km. (5 miles) from Lottstetten to Altenburg, which cross a corner of German territory. Conversely, the *Baden Railways* own the 20 km. (12.4 miles), which lie in Switzerland, of their Erzingen-Schaffhausen-Thayingen line.

The 15 km. (9.3 miles) of the Geneva-La Plaine (towards Bellegarde) line, be-

longing to the *P.L.M.* (like the 4 km. = 2.5 miles towards Annemasse) are operated jointly with the *Swiss Federal Rys.*

Among the metre-gauge railways, mention must be made of the *Soc. Ferr. Regionali Ticinesi,* which operates in Italy the 22 km. (13.7 miles) of the 52-km. (32.3 miles) Locarno and Domodossola railway and the *Soc. Nav. e Ferr. pel Lago di Lugano,* whose two lines (44 km. = 27.3 miles long altogether) lie in Italian territory.

SUMMARY OF THE FRONTIER SECTIONS.

Swiss lines operated by foreign companies . . . . . 34 km. (21.1 miles).
Swiss lines belonging to foreign companies and operated by them 43 km. (26.7 miles).
Outside Switzerland : Lines belonging to Swiss companies and operated by them 93 km. (57.8 miles).
Outside Switzerland : Lines belonging to foreign companies and operated by Swiss companies . . . . 75 km. (46.6 miles).

XXXVI-5. — Track- and loading gauges. — Two gauges, standard- and metre, are both used for main and secondary lines.

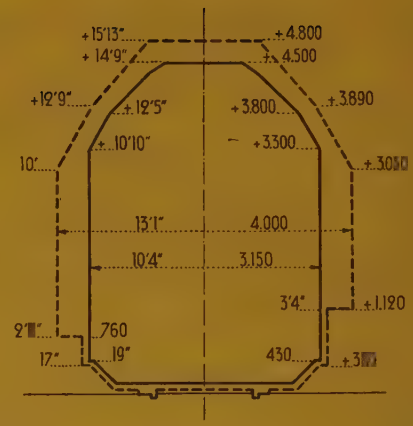
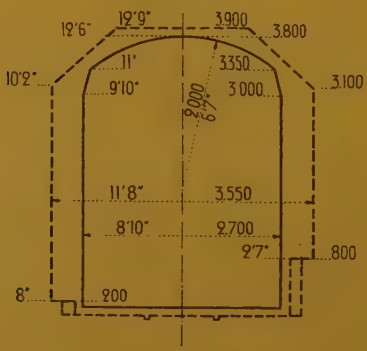


Fig. 213. — Loading and structural gauges. Swiss standard-gauge lines.

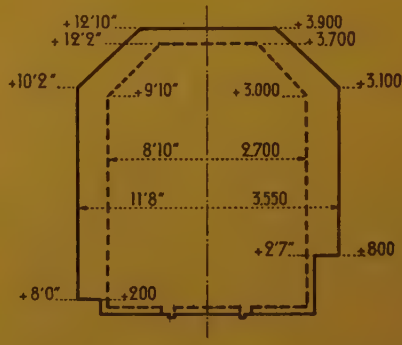
The Berne Conference settled the question of track gauges as well as loading gauges, by limiting both of them so as to facilitate international traffic.

A very few secondary lines only have been built to different gauges, less than one metre.

The loading gauges of the more important metre-gauge lines are relatively large (fig. 214).



Rhätische Bahn
and Viège-Zermatt Ry.



Montreux-Berner
Oberland Bahn.

Fig. 214. — Loading and structural gauges. Metre-gauge lines.

XXXVI-6. — **Swiss tarif distances.** — As in Austria, Swiss timetables do not quote actual distances and give tariff virtual ones, which are usually longer. They should therefore not be used for calculating train speeds and as they are frequently used in this connection we once again would draw attention to the fact. In the same way, many timetables, when quoting distances of international trains, quote indifferently these virtual or actual tariffs; such distances, therefore, should be made use of with the greatest care.

On the other hand, virtual tariff mileages are most interesting from several points of view and, as information concerning their establishment is difficult to obtain, it will serve a useful purpose to supply it here.

On Swiss railways, tariff kilometres are in every instance rounded off to the upper figure even if the extra distance is but a single metre.

The basis for tariff kilometres, on heavily graded lines, were approved by a decree of the State Council, of the 11th September 1873, which fixed the rates by applying the following coefficients of multiplication :

Maximum gradient 1 in :
100 67 50 40 33 28.5 25 22 20.

Coefficient :
1.00 1.19 1.40 1.85 1.62 2.11 2.39 2.69 3.00.

This was come to, taking general expenses into consideration; these fell under two heads :

a) General expenses which vary according to the gradient, including the cost of stores (fuel, lubricants, etc.), staff (brakesmen, etc.) and rolling stock maintenance, which were estimated at 50 % of the general working expenses.

b) Ordinary working expenses : admi-

TABLE 208.

LEADING DIMENSIONS OF LOADING AND STRUCTURAL GAUGES.

MAXIMUM DIMENSIONS.	Loading gauge.						Structural gauge.					
	Width.		Height.		Area.		Width.		Height.		Area.	
	Metres.	*Feet-in.*	Metres.	*Feet-in.*	M²	*Sq. feet.*	Metres.	*Feet-in.*	Metres.	*Feet-in.*	M²	*Sq. feet.*
STANDARD GAUGE TRACK.												
Standard loading gauge.	3.10	10′ 2″	4.28	14′ 1/2″	12.10	130	...	...	...	...	...	...
Swiss Federal Rys. . .	3.15	10′ 4″	4.50	14′ 9 5/32″	12.52	138	4.00	13′ 1″	4.80	15′ 9″	16.27	175.1
METRE GAUGE TRACK.												
M.-B.-O.	2.70	8′ 10 5/16″	3.70	12′ 1 43/64″	9.22	99	3.55	11′ 7 13/16″	3.90	12′ 9 3/16″	13.00	139.9
Viège-Zermatt	2.70	8′ 10 5/16″	3.96	13′	...	...	3.55	11′ 7 13/16″	3.90	12′ 9 3/16″	13.14	141.3
Rhätische Bahn	Do.	Do.	3.80	12′ 5 5/8″	9.40	101	Do.	Do.	Do.	Do.	13.10	140.9
Albula Tunnel Ry. . .	...	...	...	...	...	...	4.50	14′ 9 5/32″	5.00	16′ 5″	...	...
Bevers Line Tunnels Ry.	...	...	...	...	...	...	4.30	14′ 1 5/16″	4.885	16′ 5/16″	...	...

nistrative, despatching, telegraphic and miscellaneous services, which were also estimated as 50 % of the total.

c) Finally, as the rates applied should be high enough to cover the financial charges, in particular the amortisation of the initial capital, the final coefficient of multiplication was fixed, the three factors just mentioned being taken into account as shown hereafter (table 209) :

TABLE 209.

DETERMINATION OF THE COEFFICIENT OF MULTIPLICATION FIXING THE SWISS TARIFF DISTANCES.

GRADIENT.	1 in 100	1 in 67	1 in 50	1 in 40	1 in 33	1 in 28.5	1 in 25	1 in 22	1 in 20
Ratio of transport costs for a given weight .	1.00	1.38	1.80	2.24	2.70	3.22	3.78	4.38	5.00
Variable costs *a*) . . .	0.50	0.69	0.90	1.12	1.35	1.61	1.89	2.19	2.50
Fixed costs *b*)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Coefficient to be applied to the general charges.	1.00	1.19	1.40	1.85	2.11	2.39	2.69	3.00	...

The law of the 27th June 1901 ratified previous arrangements, specifying that the Railway Supervision Committee might authorise increased rates when special constructional or operating conditions should justify them.

Actually, distances on mountain sections are increased by from 25 to 118 %. The *St. Gothard Ry.*'s 13th October 1909 contract, for instance, granted an increase of 50 % (passenger rates) on 1 in 67 or steeper gradients. Since then, for other reasons, these increments have been decreased and this, in its turn, affected other railways, tariff distances.

On the *Rhätische Bahn*, certain distances are virtually lengthened by one third or two thirds of their actual length.

These additional distances differ moreover according to the class of traffic.

TABLE 210.

VIRTUAL DISTANCE LENGTHENING FOR TARIFF PURPOSES ON THE SWISS FEDERAL RAILWAYS.

SECTION OF LINE.	Gradient.	Addition, %.
Vevey-Chexbres-Puidoux (running powers) private line worked by S. F. Rys.) . .	1 in 26	118.3
Nyon-Crassier-Frontier	» 67	50
Brigue-Iselle (22 km. = 13.7 miles) . .	...	100
Basle : S. F. Rys. to Bad. St.-B. (4 km. = 2.5 miles)		
Le Day-Le Pont	» 26	50
Neuchâtel - La Chaux - de - Fonds - Le Locle-Frontier	» 37	33
Erstfeld-Bodio	» 38	40
Emmenbrücke-Beinwil-Wildegg or Münster (Lucerne)	» 33	20
Winterthur-Wald	» 33	20
Wald-Rüti (Zurich)	» 40	40
The Ricken tunnel	» 53	60
Giswil-Meiringen (1st, 2nd and luggage) .	» 8	100
Do. (3rd)	» 8	50

Thus on the *Brünigbahn*'s mountain section extending as far as Meiringen, there are different virtual distances either for 1st and 2nd-class (and luggage), or for 3rd class. From Giswil to Brünig, tariff distances are 16 or 21 km. (9.9 or 13.0 miles) respectively, while the actual distance is only 10.8 km. (6.7 miles).

For tariff purposes, the *Swiss Federal Rys.* always apply actual distances except on the sections shown in table 210.

TABLE 211.
SWISS PRIVATE COMPANIES' DISTANCE LENGTHENING FOR TARIF PURPOSES.

COMPANY.	Railway.	Addition %.
Berne-Lötschberg-Simplon	Scherzlingen-Böningen	100
	Spiez-Frutigen	20
	Frutigen-Brig	50
	The Lötschberg Tunnel	100
Berne-Neuchâtel (direct line)	Berne-Neuchâtel	25
Spiez-Erlenbach	Spiez-Erlenbach	52
METRE-GAUGE LINES.		
Berninabahn	Pontresina-Poschiavo	25
Montreux-Berner Oberland	Chamby-Allières	100
Rhätische Bahn	Landquart-Küblis	33.333
	Bevers-Schuls-Tarasp	
	Filisur-Disentis	
Do.	Küblis-Davos-St. Moritz	66.667
	Samaden-Pontresina	

There are now no longer any virtual tariff goods rates, nor is there any general rule for tariff distances although railways having similar characteristics apply the same principles. Here are a few examples of virtual tariff distances :

TABLE 212.
ACTUAL AND VIRTUAL TARIFF DISTANCES ON LINES BELONGING OR FORMERLY BELONGING TO PRIVATE RAILWAY COMPANIES.

LINE.	Company.	Distance (Km.).	
		Actual.	For tariff purposes.
Erstfeld-Göschenen	Gothard Line.	28	40
Göschenen-Airolo	Do.	16	22
Airolo-Biasca	Do.	46	62
Neuchâtel-Berne	Company.	42	54
Liestal-Waldenburg	Waldenburger Bahn.	14	19
Thun-Interlaken	Berner Alpenbahn.	27	39
Saignelégier-La Chaux-de-Fonds	Company.	27	44
Bienne-Délémont	S. F. Rys.	35	47
Ramsei-Huttwil	Company.	19	27

Naturally, the luggage rates are increased differently, and usually more so than the passenger rates, sometimes even when the latter are not subject to any virtual increase. For example :

			Tariff distance.	
			Passengers.	Luggage.
Spiez-Zweisimmen	Berner Alpenbahn.	35 km.	...	61 km.
Solothurn-Nieberbipp	...	14 km.	16 km.	29 km.

Virtual tariff distances greatly influence transport and also, of course, train services. In cases of international competition such as over the transalpine lines, any alteration of actual or virtual distances may cause, owing to existing agreements, harmful effects, even to the lines situated quite a distance away.

The first agreements of this kind were come to between the Companies operating the Brenner and St. Gothard railways. When the Simplon line was inaugurated, the agreement applied to it, in place of the St. Gothard, for transport over shorter distances in its own district. In the same way, in the case of Italo-French transport, the 1911 agreement between the St. Gothard, Simplon, Mount Cenis and Ventimiglia lines applies to the shortest and cheapest route, to all places beyond the *P.L.M.*'s own system.

As a partial exchange for the German subsidy, the *St. Gothard Ry. Co.* (whose internal rates were lower than those of the *Simplon*, built at a later date) applied, in transit, from Pino to Lucerne, (195 km. = 121.2 miles), the Prussian rates which were still lower than its own.

This caused difficulties to the Simplon line, whose rates over the 22 km. from Brig to Iselle, were still virtually increased, in accordance with the Italo-Swiss agreement in force, by an extra distance of 22 km., half of which was attributed to each of the two countries.

The additional rate for 195 km. (121.2 miles) from Pino to Lucerne corresponded to a 25.6 % lengthening of the tariff distance. The Simplon line, for an equal distance, only had to bear an 11.3 % increase. In this way, the 195 km. were counted as 245 and 217 km. respectively, in addition to the 22 contract kilometres imposed on the Simplon. As the transit rates were lower via the St. Gothard than via the Simplon, the latter line was at a disadvantage, which explains why it was not used more. It was therefore decided to apply the Prussian rates on the Simplon line as well and this for the less than 195 km. (121.2 miles) distances, the *Swiss Federal Rys.*'s rates being applied for greater distances.

Since then rates have been decreased several times on both sides. The additional Chiasso-Lucerne tariff lengthening has been reduced in the case of transit traffic from 64 to 42 km. (39.8 to 26.1 miles), and that from Pino to Lucerne from 50 to 33 km. (31 to 20.5 miles). Since the 1st of May 1920, the 35 % reductions then in force have been increased to 50 %. These reductions have been applied, in the same proportions, to the Simplon line.

CHAPTER XXXVII.

The trains.

XXXVII-1. — **General.** — The Wagon-lits trains form the backbone of the Swiss mains services but, there are also a certain number of important interna-

tional expresses (1) made up of rakes and coaches coming from or going to a number of places. These are heavy trains, running, in spite of the curves and gradients which abound on most of the lines, at relatively fast timings. Under such conditions the speed of the Lötschberg and St. Gothard expresses, for instance, is truly remarkable.

XXXVII-2. — **The Swiss sleeping- and restaurant-car services** (fig. 216). — Three Companies operate these services in Switzerland : the *International Sleeping-Car Company*, the *Mitropa*, and the *Swiss Restaurant Car Company*.

By virtue of a post-war agreement, the *Mitropa* operates sleeping-car services from Holland and Germany, to or through Switzerland, all others being operated by the *International Sleeping-Car Company*.

Moreover, Switzerland was one of the first countries having a national Company for restaurant-car services. This Company's rolling stock is very similar that of the *International Sleeping-Car Co.* (figs. 215 and 218) with which it is closely allied.

Furthermore, certain important metre-gauge lines also have — or had — Pullman and restaurant-car services.

We will deal with all these services in the following order :

a) Wagon-lits trains;

b) Isolated sleeping- or restaurant-car services;

c) Metre-gauge services.

a) The wagon-lits trains are necessarily international ones as a merely Swiss one would provide too short a run (fig. 216).

Trains from abroad to Switzerland. — There are in Switzerland three regions which, more than any others (with the exception, perhaps, of the Riviera), attract foreigners : these are the Bernese Oberland with Interlaken, the Lake of Lucerne, and the Engadine with Coire and St. Moritz. Actually, there is a fourth one of equal importance, the Lake of Geneva district, but without any apparent reason, it seems to have been overlooked.

The *International Sleeping-Car Co.* set itself the task of connecting the English, French, Belgian, Dutch and German capitals with these regions. It therefore ran trains to Basle, where they were split up and made up again so as to serve the main tourist centres with rakes coming from many places. Their make-up has varied according to prevalent economic conditions.

As English tourists used to be the most numerous, most of these trains covered English traffic but they have since been completed by rakes serving other countries.

In July 1896, the « Engadine-Interlaken-Express » started running between Calais and Switzerland which it entered via Delle. It was then split up at Délémont whence one section ran to Interlaken and another to Basle and Coire. In 1900, a third section was added from Basle to Lucerne and the train became

(1) Some of the international trains are designated by letters :

B. E. or C. E. (Boulogne or Calais-Engadine).
B. O. or C. O. (Boulogne or Calais-Oberland).
B. Z. Brussels-Zurich (Edelweiss).
G. M. Gothard-Milan.
E. F. Engadine-Francfort (All-sleeping-car train).
H. L. Holland-Lucerne (Rheingold).
M. P. Milan-Paris (Simplon-Orient).
M. Z. Milan-Zurich.
P. W. Paris-Vienna (Arlberg-Express).
D. O. Direct Orient.

Fig. 215. — Swiss Restaurant-Car Company's dining car.
Built by the Schlieren Works.

Fig. 216. — Routes of the International Sleeping-Car Company « de luxe » trains.
Discontinued services are shown by broken lines, narrow-gauge lines by a double broken line.

Table 213.

MITROPA AND INTERNATIONAL SLEEPING-CAR COMPANY SWISS TRAIN SERVICES.

ORIGIN.	Swiss run.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	—
	North-South transit.					
s Est	*Basle-Chiasso (Milan)* (1) .	319	198	R *5.44* p.m.	*5.01*	*Gothard Express* (1930).
s-Belfort . . .	*Delle-Interlaken*	167	104	*1.40* p.m.	*4.06*	*Do.*
	Zurich-Chiasso (Milan) . .	241	149	R *5 44* p.m.	*4.56*	*Do.*
na-Strasbourg .	*Basle-Chiasso (Genoa)* . .	319	198	*10.20* p.m.	*7.30*	*Lloyd Express* (2). (until 1913).
terdam, The Ha-	*Basle-Chiasso (Genoa)* . .	319	198	*5 13* a.m.	*6.27*	*Lloyd Riviera* (1914).
e or *Berlin* . .	*Do. -Coire*	206	125	*5 07* a.m.	*4.18*	*Do.*
n	Basle-Chiasso (Ventimiglia)	319	198	12 05 a.m.	4.52	Riviera Express.
	West-East transit.					
is-Paris Est . .	Basle-Zurich-Buchs (Orient)	197	122	3.48 a.m.	2.52	Arlberg-Orient Express.
is-Paris P. L. M.	Vallorbe-Brig (Orient) . .	192	119	R 10.58 p.m.	2.54	Simplon-Orient Express.
	Swiss services to abroad.					
terdam, The Ha-	*Basle-Zurich-Coire*	206	125	*5 03* a.m.	*4.41*	*Amsterdam and Switzerland Express.*
e or *Berlin* . .						
nd or *Berlin* .	*Do. -Lucerne*	95	59	*5.57* a.m.	*2.13*	*Ostend-Berlin Switzerland.*
terdam or *Berlin.*	*Do. - Do. -Coire* . . .	206	125	*5.07* a.m.	*4.18*	*Lloyd-Riviera Exp.* (1914).
is-Paris Est . .	*Do. - Do. - Do.* (3) . .	206	125	3.48 a.m.	3.33	Engadine Express.
	Basle-Zurich-Coire (BA) .	206	125	7 *17* a.m.	*3.29*	MITROPA *sleep.-car train.*
terdam, The Ha-	*Do. -Lucerne-Lugano* (B) .	303	188	*6.40* a.m.	*5.14*	*Do.*
e or *Berlin* . .	*Do. -Bienne-Geneva* (B) .	238	148	*7.45* a.m.	*4 08*	*Do.*
	Do. -Interlaken (BH) . .	169	105	*6.55* a.m	*2.59*	*Do.*
terdam	Basle-Lucerne	94	58	R 7.15 a m.	1.25	Edelweiss (Sl. Car. Co.) and
	Do. Zurich (HB)	93	58	R 7.22 a.m.	1.23	Rheingold (MITROPA).
is-Paris P. L. M.	*Verrières-Interlaken Ost* .	142	88	*4.30* a.m.	*3.15*	*Oberland Express* (4).
is-Paris Est . .	Delle-Interlaken Ost . . .	167	104	6.06 a.m.	3.48	Oberland Express.
s P. L. M. . . .	Bellegarde (5)-Geneva . .	15 (6)	9	8.00 p.m.	0 39	Savoie Express (7).
	Home services.					
...	*Montreux-Zweisimmen* . .	62	39	*11 10* a.m.	*3.48*	*Golden Mountain Express.*
				R *10.43* a.m.	*3.35*	M.-B. O.
...	*Coire-St. Moritz*	89	55	R 8.00 p.m.	2.30	*Engadine Express* (Rh. B.).

(1) Originally from Basle only.

(2) There was also a Berlin-Strasbourg-Lyons-Ventimiglia rake.

(3) In 1911, this train stood in Paris Nord from 10.18 to 10.57 a. m. and in Paris Est from 5.18 to 5.47 p. m. It left Delle at 3.03 a. m.

(4) This obsolete « Oberland Express » left Paris P. L. M. at 8.05 p. m. (9.0 p. m., Swiss time).

(5) The time given refers to Bellegarde.

(6) The kilometrage, to La Plaine (frontier).

(7) The « Savoie Express » also included a Bellegarde—Evian-les-Bains rake and also a Culoz-Chambéry rake.

known as the « Calais-Lucerne-Interlaken-Engadine Express ». This train avoided Paris and ran from Calais by a roundabout route via Lille, Douai and Chaumont to Basle, whence it served the three principal Swiss centres, whose popularity increasing, a Paris-*Est*-Chaumont rake was added and three new trains added in 1901 :

The « Ostend Swiss Express », from Ostend, via Strasbourg to Basle and Lucerne;

The « Berlin Swiss Express », from Berlin to Strasburg, where it joined up with the Ostend one;

And the « Amsterdam Swiss Express », made up at Utrecht of two sections which started from Amsterdam and the Hague and ran to Basle along the Baden side of the Rhine, then onward to Zurich.

Distances and journey times at this period are shown in table 214.

The Lucerne rakes from Calais-Paris, Ostend and Berlin were formed into a single train at Basle, as were the Amsterdam—The Hague and Calais-Paris rakes to Coire.

Since then, the entire services have been altered. The « Engadine Express's starting point was transferred from Calais to Paris-*Est*, and a new « Oberland Express », starting from Paris *P.L.M.*, ran solid with the « Simplon Express » which then proceeded as far as Milan only. Coire was also served by a rake from the « Lloyd-Riviera Express » (from Altona, Berlin and Holland), which was detached at Basle.

Post-war economic conditions made further changes necessary. Night sleeping-car and day Pullman-car trains were introduced and many of the international itineraries altered.

Among the new trains, were two all-sleeping-car ones, belonging respectively to the *Sleeping Car Co.* and to the *Mitropa*. The former was a « Paris-Switzerland Express », a through Paris and Vienna train, which has since developed into the « Arlberg Orient Express ». It included, at first, a Lyons-Coire rake as well.

The latter comprised the following sleepers :

Berlin and Amsterdam—Coire.
Berlin —Lugano.
Berlin and The Hague—Interlaken.
Berlin —Geneva.

These were the first Lugano and Geneva services — and very rational ones.

Finally the « Engadine Express » was amalgamated with a new « Oberland Express » run via Belfort and Delle by the *Est Co.* The transfer of an international train from the *P.L.M.* to the *Est* system is one of the rare occurrences of international competition between two French railways. Below, we give comparative distances by the *P.L.M.* and *Est* routes, together with those from Calais to Basle by the old route (via Lille), the distance by the present route (Amiens, Laon, and Chaumont) and finally that serving Paris on the way, making use in turn of the *Nord*, *Ceinture* and *Est* Rys.

	Paris Est-Basle-Sonceboz.	Paris Est-Delle-Granges.	Paris P. L. M. Pontarlier.
Paris to Interlaken . . .	770 km. (478.5 miles).	645 km. (400.8 miles).	610 km. (379 miles).
Calais to Interlaken . . .	1 123 km. (697.8 miles).	902 km. (560.5 miles).	918 km. (570.4 miles).

Acute similar competition still exists for the Dutch-Swiss traffic, two Pullman trains, the « Edelweiss » and the « Rheingold » running daily from Amsterdam

Fig. 217. — Recent metal coach, Swiss Federal Railways.
Built by the Schlieren Works.

Fig. 218. — Swiss Restaurant-Car Company's coach.
Built by the Schlieren Works.

TABLE 214.

ROUTE TAKEN BY FORMER « SWISS EXPRESS » TRAINS.

RUN.	Distances.		Time spent.
	Km.	Miles.	
Paris-Delle-Basle	544	338.0	
Paris-Basle-Interlaken	770	478.5	12 h. 30
Do. -Basle-Lucerne	639	397.1	12 h. 25
Do. -Basle-Coire	749	465.4	13 h. 59
Calais-Lille-Delle-Basle	897	557.4	
Calais-Basle-Interlaken	1 123	697.8	16 h. 25
Do. -Basle-Lucerne	1 218	756.8	16 h. 20
Do. -Basle-Coire	1 102	684.8	17 h. 54
Ostend-Basle-Lucerne	801	497.7	15 h. 20
Berlin-Basle-Lucerne	982	610.2	16 h. 30
Amsterdam-Basle-Coire	1 007	625.7	20 h. 24
The Hague-Basle-Coire	907	563.6	20 h. 59

Fig. 219. — *International Sleeping-Car Company's* sleeping-car routes. Discontinued services are shown by broken lines.

to Basle on the Western and Eastern banks of the Rhine (1). Each of these trains comprises two rakes, one to Zurich and (during the season), another to Lucerne. It is amusing to note that beyond Basle, both Companies' rakes to each place run coupled together in— let us suppose — complete harmony.

The « Rheingold » also includes through coaches from the Hook of Holland.

TRANSIT « DE LUXE » TRAINS. — Three series of trains come under this heading :

North to South trains connecting Holland and Germany with Italy. These were formerly the « Lloyd Express » and « Riviera Express ». The latter now runs again, but it has been rerouted outside Switzerland.

The former « Gothard Pullman Express », from Basle to Milan, was soon extended as far as Paris. A Paris-Delle-Interlaken rake was even included for a short time, but this train did not last long and has been suppressed owing to the present economic crisis.

In the West to East direction, the « Switzerland-Arlberg-Vienna Express », an all-sleeping-car train, has become the « Arlberg-Orient Express ». For part of the journey the « Engadine » and the « Oberland Express » run solid with it.

Finally the « Simplon-Orient Express » runs through the South-Western part of Switzerland.

Fig. 220. — *Mitropa*'s sleeping-car services (thick lines) and restaurant-car metre-gauge services (thin double stepped lines).

(1) The distance from Amsterdam to Basle S. F. Rys. is 817 km. (507 miles) via Brussels Nord, and 781 km. (485.3 miles) via Cologne.

Fig. 221. — *International Sleeping-Car Company*'s restaurant-car services.

The Lötschberg line has never boasted a « de luxe » train.

b) **Isolated sleeping- and restaurant-car services.** — There are now 78 sleeping-car, eight restaurant-car and 6 « de luxe » train services in Switzerland, divided up between the three companies as stated in table 215.

We have shown the *Mitropa* services (2) in figure 220 and those of the *Swiss Company* in figure 222.

(2) List of services operated by the *Mitropa* (with the distances quoted by this Company) :

Via Basle.

	Km.	*Miles.*	*Time.*
Amsterdam-Cologne-Coire .	981	609.6	17.2
	1 033	641.9	21.3
Amsterdam-Cologne-Interlaken	941	584.7	17.5
	1 001	622.0	22.0
Berlin Anhalt - Francfort - Coire	1 084	673.6	18.3
Berlin Anhalt - Francfort - Interlaken	1 045	649.3	18.6
Berlin Anhalt-Bienne-Geneva	1 107	687.9	19.5
	1 115	657.9	19.5
2 Berlin Anhalt-Bienne-Lugano services	1 181	733.8	18.8
	1 173	728.9	18.8

Via Lindau.

	Km.	*Miles.*	*Time.*
Berlin-Stuttgart-Zurich . .	897	557.4	15.9
Berlin-Coire	910	565.5	16.8
Munich-Zurich	357	221.8	7.5
Nuremberg-Zurich . . .	466	289.6	8.7

TABLE 215.

NUMBER OF SLEEPING-, PULLMAN- AND RESTAURANT-CAR SERVICES.

CLASS OF COACH.	Service.	Company.		
		Mitropa.	Sl.-Car. Co.	Swiss Co.
De luxe trains	International	8 (1)	8	...
	Transit	...	6	...
Day trains	International (2)	4	4	...
Sleepers	International	30	32	...
	Transit	...	16	...
	Home	...	...	...
Diners	International	...	14	...
	Transit	...	...	...
	Home	...	6	40
Dining cars for metre-gauge track	International	2	...	...
	Home	8	...	...

Fig. 222. — *Swiss Restaurant-Car Company*'s dining-car services.

(1) All these services are covered by the same sleeping-car train which is divided into four sections at Basle.

(2) Although only two international trains run each way in Switzerland, they had to be included both among those of the *Mitropa* and of the *International Sleeping-Car Company* as each of them includes a rake belonging to each of these two Companies.

a) Montreux-Berner Oberland Bahn.
Interior view of metre-gauge coach.

b) Pullman coach, Rhätische Bahn.

Fig. 223. — Interior of « de luxe » stock built by the Schlieren Works for Swiss metre-gauge lines.

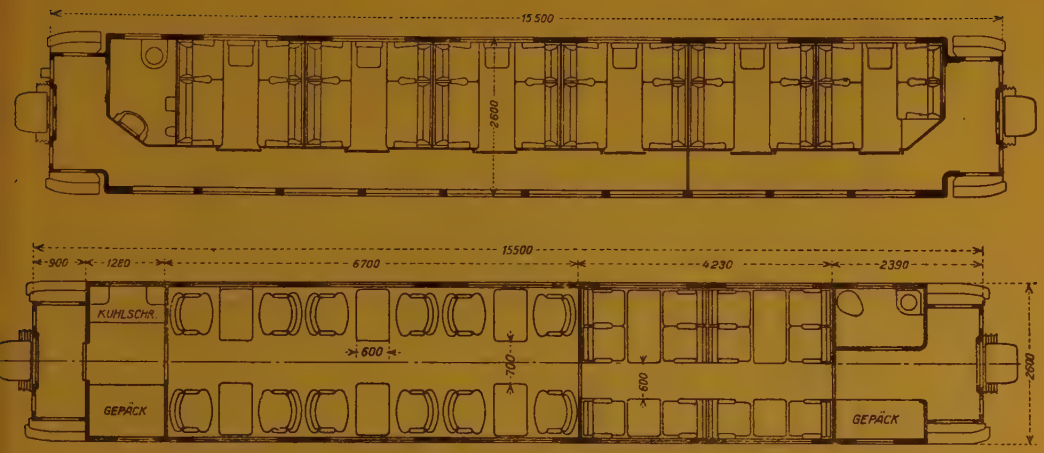


Fig. 224. — Rhätische Bahn (metre gauge).
1st-class coach and Pullman car.

Fig. 225. — Rhätische Bahn (metre gauge).
Coach built by the Schlieren Works.

Fig. 226. — Montreux-Berner Oberland Bahn (metre gauge).
Coach built by the Schlieren Works.

Swiss mileages worked over by each of the three Companies are as follows :

The *Swiss Restaurant-Car Company* operates 1 250 km. (776.7 miles) of line, while the *International Sleeping-Car Company*'s dining-car services cover

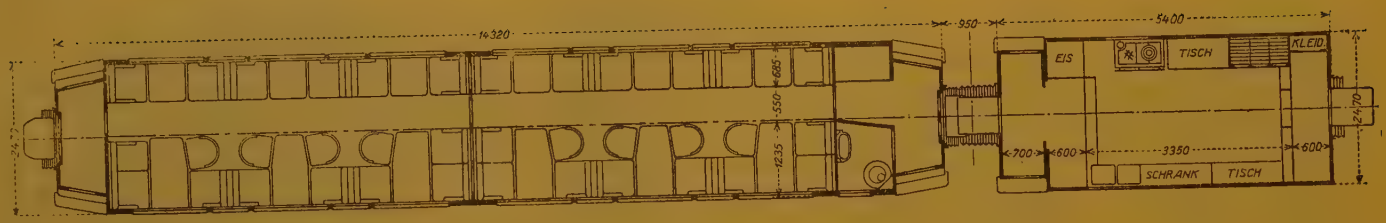


Fig. 227. — Bernina Railway (metre gauge).
Mitropa restaurant car and kitchen car.

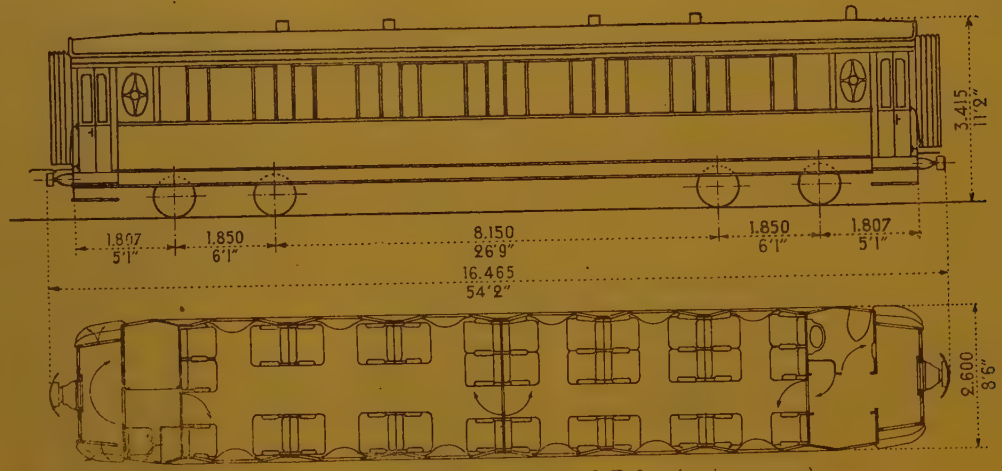


Fig. 228. — Montreux-Berner Oberland Bahn (metre gauge).
1st-class carriage.

Table 216.

LEADING DIMENSIONS OF PULLMAN- AND RESTAURANT CARS

on Swiss metre-gauge lines.

CLASS OF CARRIAGE.	Pullman.	Saloon.	Pullman.	Diner.	Diner.	Kitchen.	2nd- 3rd cl.
Railway system	M. B. O.	Rh. Bahn.	Rh. Bahn.	Rh. Bahn.	Bernina.	Bernina.	Bernina.
Owning Company	Sl. Car. Co.	Rh. Bahn.	Rh. Bahn.	Mitropa.	Mitropa.	Mitropa.	Bernina.
Length, overall	16.465 m. 54′ 1/4″	16.44 m. 53′ 11 1/4″	16.44 m. 53′ 11 1/4″	16.44 m. 53′ 11 1/4″	15.27 m. 50′ 1 3/16″	6.35 m. 20′ 10″	13.91 m. 45′ 11/16″
Body length	15.465 m. 50′ 9″	15.50 m. 50′ 10″	15.50 m. 50′ 10″	15.50 m. 50′ 10″	14.32 m. 47′	5.10 m. 16′ 8 13/16″	13.05 m. 42′ 9 25/32″
Body width	2.680 m. 8′ 9 1/2″	2.60 m. 8′ 6 5/16″	2.60 m. 8′ 6 5/16″	2.60 m. 8′ 6 5/10″	2.47 m. 8′ 1 1/4″	2.47 m. 8′ 1 1/4″	2.36 m. 7′ 9″
Outside height	3.415 m. 11′ 2 1/2″	3.455 m. 11′ 4″	3.45 m. 11′ 3 3/16″	3.45 m. 11′ 3 3/16″	3.35 m. 11′ 1/8″	3.35 m. 11′ 1/8″	3.41 m. 11′ 2 9/32″
Bogie wheel base	1.85 m. 6′ 13/16″	1.70 m. 5′ 7″	1.70 m. 5′ 7″	1.70 m. 5′ 7″	2.00 m. 6′ 6 3/4″	3.00 m. 9′ 10 1/8″	2.00 m. 6′ 6 3/4″
Distance between bogie centres	10.00 m. 32′ 9 3/4″	11.20 m. 36′ 9″	11.20 m. 36′ 9″	11.20 m. 36′ 9″	8.75 m. 28′ 8 1/2″	... ...	8.00 m. 26′ 3″
Wheel diameter	0.76 m. 2′ 5 7/8″	0.75 m. 2′ 5 1/2″	0.75 m. 2′ 5 1/2″	0.75 m. 2′ 5 1/2″	0.75 m. 2′ 5 1/2″	0.75 m. 2′ 5 1/2″	0.85 m. 2′ 9 1/2″
Seats, number	32	35	12 + 12	36	36	...	12 + 31
Weight, empty . . . Metr. t. *(Engl. t.)*	18.8 18.5	26.4 26.0	24.0 23.6	26.0 25.6	18.2 17.9	6.05 5.95	... ...
Weight per passenger . Metr. t. *(Engl. t.)*	0.587 0.578	0.720 0.708	1.000 0.984	0.720 0.708	0.510 0.502	... ...	... ...

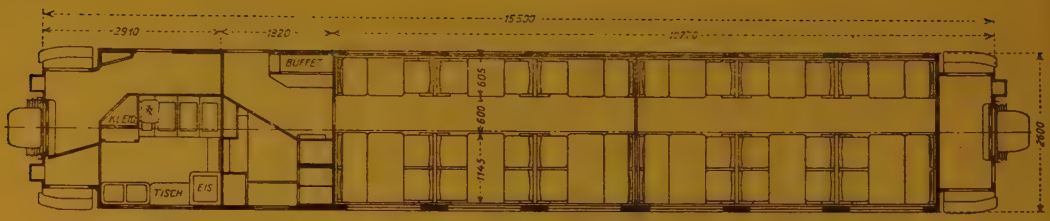


Fig. 229. — Rhätische Bahn (metre gauge).
Mitropa restaurant car.

Fig. 230. — Federal Railways.
Inside of recent metal coach, built by the Schlieren Works.

1 018 km. (632.6 miles), 584 km. (362.9 miles) of which are common to the two companies.

The *Mitropa* sleeping cars serve 812 km. (504.6 miles) of line in Switzerland, 182 km. (113.1 miles) of which are also used by its « Rheingold Express », while the *Sleeping-Car Company*'s sleeping cars serve 1 136 km. (643.7 miles), 706 km. (438.7 miles) of which are also used by its « de luxe » trains.

The rolling stock does not include any very special vehicles. It is interesting to point out, however, that a double-deck sleeping car has recently been designed by the Schlieren Rolling Stock and Lift Works, developing a suggestion put forward, in 1928, in *The Locomotive*.

c) **Services over metre-gauge railways.** — On the *Montreux-Oberland Bahn*, the *Rhätische Bahn* and the *Bernina Bahn*, Pullman, restaurant cars, and even « de luxe » trains have been introduced.

« De luxe » trains. — On the *M.O.B.*, the « Golden Mountain Express », of the *International Sleeping-Car Co.* was an all-Pullman train which, from the 1st July to the 30th September 1931, ran non-stop from Montreux to Zweisimmen in 3 h. 35 m. Another standard-gauge train extended it from Zweisimmen to Spiez.

The « Engadine Express » of the Rhätische Bahn is a continuation, on its metre-gauge line, of the International *Sleeping-Car Co.* 's train. It includes 1st and 2nd-class coaches (formerly 1st-class only) besides a *Mitropa* restaurant car.

Isolated services on metre-gauge lines. — The International *Sleeping-Car Company* ran Pullman cars over the *M.O.B.*, and the *Swiss Company*, restaurant cars.

Pullman type coaches, on the *Rhätische Bahn*, belong to this railway Company (fig. 223*b* and 224).

a) Interior of restaurant car.

b) Outside view.

Fig. 231. — Bernina Railway (metre gauge).
Mitropa restaurant car.

Finally, the *Mitropa* operates restaurant-car services between Coire and St. Moritz (1) *(Rhätische Bahn)* and between St. Moritz and Tirano *(Bernina)*.

The coaches used on these services are most interesting. They are shown in figures 227, 229 and 231.

The *M.O.B.* Pullman coaches (figs. 226 and 228) have a luggage compartment, lavatory, etc. The *Rhätische Bahn* 's si-

(1) The *Rhätische Bahn*'s three restaurant cars are included three times a week in the « Engadine Express », and summer and winter in three through trains running daily in both directions between Coire and St. Moritz.

Between the two seasons, they work between Coire and St. Moritz, and between Coire and Davos and back.

milar coaches have a large saloon (figs. 223 to 225); the 1st-class coaches have six compartments and a lavatory (fig. 224).

The *Mitropa* owns two types of metre-gauge restaurant cars. That of the *Rhätische Bahn* (fig. 229) includes a kitchen; that of the *Bernina* Bahn (fig. 227) has none, and a four-wheeled kitchen vehicle with a single vestibule is coupled to the restaurant car. The question of weight is of still greater importance on this latter railway than on the *Rhätische Bahn*, gradients reaching as much as 1 in 14 (fig. 211), while the maximum gradient on the *Rhätische Bahn* is only 1 in 22.

Generally speaking, these well-designed vehicles compare favourably with standard-gauge stock.

XXXVII-3. — **Swiss rolling stock** was among the first to be equipped with vestibules ang gangways.

The new all-metal vehicles for internal services (figs. 217 and 230) differ from the previous ones in that the distance between bogie centres has been increased by 1.65 m. (5 ft. 5 in.) in order to reduce the overhang to 2.80 m. (9 ft. 2 1/4 in.) from the centres to the end of the buffers. The wheels are smaller, being only 1.10 m. (3 ft. 7 5/16 in.) diameter for use with the new Krupp springs. The bogies weigh 5 850 kgr. (5.76 Engl. tons) instead of the 5 050 kgr. (4.97 Engl. tons) of the design they replace.

Following the general tendency, the bogie wheel base of the new vehicles has been increased from 2.600 m. (8 ft. 6 23/64 in.) to 3.000 m. (9 ft. 10 1/8 in.).

TABLE 217.

LEADING DIMENSIONS OF SOME RECENT STANDARD-GAUGE VEHICLES.

RAILWAY.	Sw. F. R.	Swiss Co.	Sw. F. R.	Sw. F. R.	Sw. F. R.
Type	3rd-class.	Diner.	3rd-class.	3rd-class.	1st, 2nd, 3rd
Date	1931	...	1934	...	1932
Overall length	19.86 m. 65′ 2″	20.40 m. 66′ 11″	20.40 m. 66′ 11″	20.40 m. 66′ 11″	21.40 m. 70′ 2 9/16″
Body length	16.73 m. 54′ 10 11/16″	17.40 m. 57′ 1″	17.03 m. 55′ 10 21/32″	17.10 m. 56′ 1 1/4″	18.10 m. 59′ 4 5/8″
Body width	2.92 m. 9′ 7″	2.92 m. 9′ 7″	2.92 m. 9′ 7″	2.92 m. 9′ 7″	2.92 m. 9′ 7″
Outside height	3.855 m. 12′ 7 25/32″	3.95 m. 12′ 11 33/64″	3.96 m. 13′	3.85 m. 12′ 7 19/32″	3.96 m. 13′
Bogie wheelbase	2.50 m. 8′ 2 7/16″	2.50 m. 8′ 2 7/16″	2.60 m. 8′ 6 23/64″	2.60 m. 8′ 6 23/64″	3.00 m. 9′ 10 1/8″
Distance between bogie centres.	13.30 m. 43′ 7 5/8″	13.50 m. 44′ 3 33/64″	14.80 m. 48′ 6 45/64″	14.80 m. 48′ 6 45/64″	14.80 m. 48′ 6 45/64″
Bogie wheel diameter	1.04 m. 3 ft. 5″	... ...	0.94 m. 3′ 1″	0.94 m. 3′ 1″	0.94 m. 3′ 1″
Seats, number	80	52	72	78	6+18+32
Dead weight { Metr. t. / Engl. t.	37 36.4	... ...	38 37.4	38 37.4	45 44.3
Weight per passenger { Metr. t. / Engl. t.	0.462 0.455	... ...	0.528 0.519	0.487 0.479	0.804 0.791
Builder	Schlieren.	Schlieren.	Schlieren.	Schlieren.	Neuhausen.

(To be continued.)

[621. 131]

Is the steam locomotive out of date?

Address before the Deutsche Maschinentechnische Gesellschaft on the 17th April 1934.

by Prof. Dr.-Ing. H. NORDMANN, Reichsbahnoberrat, Berlin.

(Glasers Annalen.)

Modern rail motor vehicles favoured by the Press. Thermal efficiency of recent steam locomotives. Their suitability for low and for high powers. Attainment of high running speeds.

When, at the end of 1932 or the beginning of 1933, the fast railcar then undergoing its trials ran into Hamburg, the station and neighbouring roads were crowded. In the same way, last spring the trial runs from Saalfed to Bamberg passing over the heavy Probstzella-Rothenkirchen gradient drew an immense crowd of spectators, not only at Saalfeld and Bamberg, but also all along the line. The railwayman rejoiced to see that, alongside the automobile and aircraft, an exceptional performance on the railway also raised such interest and enthusiasm. The press were invited several times to travel with or to visit the vehicle, and issued bulletins as for a famous patient, when in the early days a run had to be cancelled, and this publicity had its due effect. Although those who made the run from Hamburg or Berlin solely for the pleasure of travelling in the railcar were probably not many, the « Flying Hamburger » undoubtedly revived public interest in the railway.

However, the steam locomotive did not meet with the same success in our time. True, it has occasionally caught public attention; when the Munich-Stuttgart line was opened to electric operation, the eminent men present eulogised the services rendered by the superseded steam engine in words agreeable to hear by those who, by duty and inclination, had remained faithful to it.

No one can deny that the press neither gives nor receives such detailed information on steam traction as it does on rail motor cars and electrification. The papers remained silent about the fast trial runs made with steam locomotives on the Hamburg line, as on those over the Probstzella bank, where the railcar times have either been followed exactly or nearly so. When the « Flying Hamburger » was not run, the steam train replacing it was only given the briefest notice. The fact that the steam train very closely approached the speed range on which the *railcar* was so complimented, and that it did it when hauled by our new *standard express locomotive* did not appear worthy of notice.

Nor can I remember seeing any press mention of corridor train 23/24, on the Hamburg line, the first German express to appear in the 1933 summer timetables, running at a commercial speed of over 100 km. (62 miles) an hour, and reaching in round figures 105 km. (65.3 miles). The speed of this train in the present winter service was increased to 111 km. (69 miles) an hour (Berlin-Hamburg 111.8 km. = 69.5 miles, and Berlin-Hamburg 109.6 km. = 68.1 miles an hour). So far as I know this is the fastest steam train running any relatively long distance.

There is much talk at the present time of canvassing traffic. Is any adequate effort made to attract traffic to the railway whilst the press gives the

impression that a good railway service is only possible with rail motor cars or electric traction? Is there any real need to cover modestly, as with a mantle represented by the 10 % of railcars and electric locomotives, the steam services still forming 90 % of the whole operation? In Germany, any reproduction of the « Rheingoldzug » only shows the comfortable carriages; when the English illustrate the « Flying Scotsman », they are careful not to forget the L.N.E.R. *Pacific* hauling it.

The true opinion of large numbers of the public as well as of railwaymen on steam operation is far from being so poor a one. The steam engine is old but is it not robust in its old age ? This theory is sometimes upheld in the technical press, when the latter deals with rail motor cars and diesel locomotives, and demonstrates their superiority over the steam locomotive, which so far has been the backbone of the railways. This attitude of the press is the more forcible, speaking sarcastically, the less the knowledge of the steam locomotive and its real qualities possessed by the authors. After all the partisans of vehicles with modern motors have to be pugnacious, as the old civilised countries are saturated as regards railways, and there is no question of building new railways for new types of locomotives, and rail motor cars which consequently can only find a place by taking that of the steam locomotive. The steam locomotive is, therefore, on the defensive. The question is to know if its position is seriously menaced so that the steam men form, as it were, the rearguard, or if it remains strong and impregnable.

If we ask ourselves what are the weak points of the steam locomotive we probably begin by thinking of its economic value. The price per ton of the usual steam locomotive is lower than that of any other kind of locomotive; we also know that as the result of standardisation and the modern reorganisation of shops, the steam locomotive will run very long distances between heavy repairs. The question, therefore, is reduced to its fuel consumption figures. Have any improvements been made in this direction in recent years? Can not the invigorating feeling of success draw its inspiration, not only from the greater size and power of the locomotives, but also from consumption figures showing a higher *specific* value ? Let us keep in mind the principle, based on long experience with mechanical construction, that when a machine has passed through a long period of evolution, and its efficiency has been greatly bettered, it becomes more and more difficult to improve it to any great extent. I would like to point out here that we can, of course, be satisfied with efficiencies such as that of the electric transformer or of the steam engine part of the locomotive conditioned by frictional losses. The greatest progress in heat economy, i.e. that due to superheating, had been made before the world war. About the same time, the feed water heater using part of the exhaust steam to raise, without any extra fuel consumption, the temperature of the feed water to 80-100° C. (176 to 212° F.) before entering the boiler, began to be fitted and is today in general use. It would almost seem as though any better efficiency was nearly impossible with the ordinary type of locomotive.

In spite of this it has been achieved. If saturated steam is a working fluid physically invariable, superheated steam is only so when its temperature is known. Now, this temperature, always related to the total working capacity of the locomotive, has been raised very considerably in recent locomotives. Formerly it reached 300° C. (572° F.) or exceeded this but little; there was some doubt if the available oils would retain their lubricating value at temperatures over 350° C. (662° F.) and if the super-

heater bends would stand it. A special damper was fitted so that the fireman could reduce the flow of the combustion gases when the pyrometer needle reached the red line marking the dangerous value of 350° C. (662° F.). Most of the locomotives were not able to reach this figure; this was the case, for instance, with the fine South-German four-cylinder compounds with their small superheaters. The class G 8_1 locomotive, with 14 kgr. (199.1 lb. per sq. inch) boiler pressure against the 12 kgr. (170.7 lb.) of the simple-expansion engines, was the only one able to supply steam at about 370° C. (698° F.) after the damper had been removed. The consumption figures of these engines are nearly as good as those of our modern locomotives, and we should not regret our large stock of G 8_1 locomotives were it not that, owing to their short wheel base, they run so badly and consequently do not lend themselves to high goods train speeds. Another engine with a good thermal efficiency was designed twenty years ago, the S 10_1. Its good qualities do not lie in the temperature reached, about 350° C. (662° F.), but in its four cylinders, the moderate size of which made it possible to get, in the cylinder block, straight steam passages of large cross sectional area. This gave us a good compound engine which, in the zone of its maximum power showed consumption figures as good as those of the standard locomotives.

One may be slightly astonished that these results, only really appreciated in the last few years, appear to be due to chance rather than to accurate calculations made beforehand. But this knowledge is really the fruit of a series of locomotive *tests;* One of the latest German locomotives, the well known P 10, is far from equalling the standard locomotives in steam and coal consumption, in spite of its good qualities, high tractive effort and smooth riding as a three-cylinder engine, and this inferiority is explained by its lower steam temperature. It is the low superheat obtained with the P 10 that led to the design of more efficient superheaters.

Apart from the locomotives mentioned above (G 8_1, and S 10_1), the old class of locomotives, excellent in their time, with a boiler pressure of 12 kgr. (170.7 lb.) and moderate superheat, is best represented by the well known P 8, much appreciated because of its general utility and ability to work overloaded trains (fig. 1). With a normal load—and

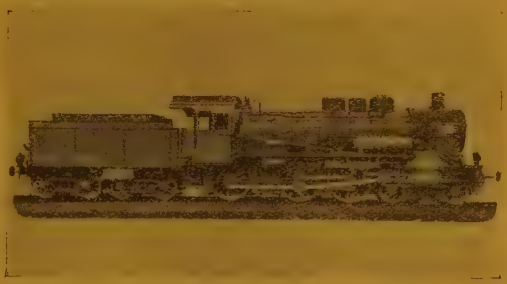


Fig. 1. — 4-6-0 passenger locomotive, class 38 (P 8).

this will be used in all comparisons because, whilst worse conditions are always possible, they are indefinite — this locomotive consumes on the average 7.35 kgr. (16.2 lb.) of steam per indicated H.P./hour and barely 1 kgr. (2.20 lb.) of 7 000-cal. (12 600 B.T.U./lb.) coal. The consumption per drawbar H.P./hour. varies much more, seeing that the consumption properly speaking of the locomotive increases with the speed. No average value can be given; the consumption is 1.42 kgr. (3.13 lb.) per effective H.P./hour at 100 km. (62 miles) an hour. To prevent false comparisons, with stationary engines, this consumption, be it noted, includes not only the mechanical friction of the engine properly speaking, but also that of the carrying wheels and of the tender and the air resistance, already appreciable at this high speed.

The result of the higher superheat,

and boiler pressure of 14 to 16 kgr. (199.1 to 227.6 lb. per sq. inch.) which now has generally replaced that of 12 kgr. (170.7 lb.) is that the standard locomotive, the $S10_1$ and the Bavarian S 3/6 are running at sometimes well below 7 kgr. (15.45 lb.) per indicated H.P/hour. The average value — arrived at in the same way — of the 01 and 03

Fig. 2. — Standard 4-6-2 express locomotive, class 03.

express locomotives (fig. 2) is 6.5 and 6.3 kgr. (14.35 and 13.9 lb.) per indicated H.P./hour. The compounds, S 10_1, S 3/6, and 02, even show better results up to 80 km. (49.7 miles) an hour, although their consumption curves rise more markedly at high speeds.

This result, chiefly ascribed in the case of the standard locomotives, to their higher steam temperatures, up to 400° C. (752° F.), is reflected in a steam saving of 11 to 13 % in weight relatively to the P 8, and to the P 10, the latter slightly worse, and inversely in an almost equal increase in the *specific efficiency* when the boilers are called upon to produce the same weight of steam per unit of heating surface. The *heat economy* is not quite so great, proportionally, as more highly superheated steam has a higher heat value. Nonetheless, there is still a saving of fuel, the consumption frequently being below 0.9 kgr. (2.0 lb.) per I.H.P.; this saving is generally from 5 to 10 %.

As regards the draw-bar horse-power, i.e. the specific consumption for the train itself, at 100 km. (62 miles) an hour, the figures are 1.33 kgr. (2.95 lb.) for the 03 and 1.27 kgr. (2.79 lb.) for the 01 (with a standard 7 000-cal. (12 600 B.T.U./lb.) coal, compared with 1.42 kgr. (3.13 lb.) per effective H.P./hour for the P 8, or a reduction of 6 to 11 %. The same difference is found in the case of the large goods locomotives, compared with the older engines such as the G 12; the class 64 tank engines for example, are better than the older T 12 engines, still frequently seen on the Berlin Metropolitan.

Before modern test methods had so clearly demonstrated the double fact that a slightly higher boiler pressure and a much greater increase in the temperature give very great savings whilst retaining the same principle of construction, endeavours were made some ten years or so ago to get greater temperature drops by various means. The fact that a greater temperature drop improved the efficiency of the engines was known long ago through the mechanical theory of heat. But, the step consisting in raising the upper limit of temperature and pressure, or lowering the lower limit was a much more serious proposition than with stationary engine design. If the bottom temperature were tackled, by condensing, the use of the exhaust steam for draught purposes was to be given up and a special fan substituted for it, to replace the bulky cylinders by a *turbine* and reduction gear, and finally to use as auxiliaries in addition to the condenser, a circulating pump for the condenser cooling water, an air pump, a water pump for emptying the condenser by suction, and cooling the water heated in the condenser, by means of a fan or large trickling surfaces. This great complication is, it must be admitted, made up for by a fuel saving of as much as 40 % compared with the P 10 which, being the most powerful reciprocating engine at the time of the or-

der, was used for comparison; relatively to the 01, the proportion would be about 25 %. However, these results are only obtained under normal working conditions. Now, any variation from the latter gave rise to very unfavourable results. Whereas with the reciprocating engine, the steam consumption, which varies with the cut-off, is approximately proportional to the *distance travelled*, and is therefore small enough at low speeds, the turbine acts by the pressure of the steam jet on the blades, and sufficient energy must still be exerted when the locomotive is moving slowly, especially under load.

In unit time, therefore, much steam is used in spite of all, so that in tests of the turbine locomotive on the same work as a class 01 locomotive, the starting period and the light engine running from and to the shed absorbed the whole saving made in train working. Although it has been much discredited as a result of these trials, the turbine locomotive will be tried again after a long interval with new auxiliaries, foremost of which must be mentioned a shunting and starting turbine which can be thrown out of gear and acts as a reserve gear. Thanks to a very large gear ratio, the small locomotive speeds will then come within an efficient range of turbine speeds i.e. that with which the specific steam consumption is low, so that most of the work done from starting up to the cutting out speed, will then be done with this turbine under conditions favourable to a small steam consumption, whereas the part of the work done by the main turbine will show a high steam consumption relatively to time. Then too any running in back gear will be done with the small turbine.

A design of this kind has been adopted from the start on a proposed new turbine locomotive, fired with pulverised coal, for very fast trains up to 160 km. (100 miles) an hour, and developing 3 000 I.H.P. and over. This locomotive

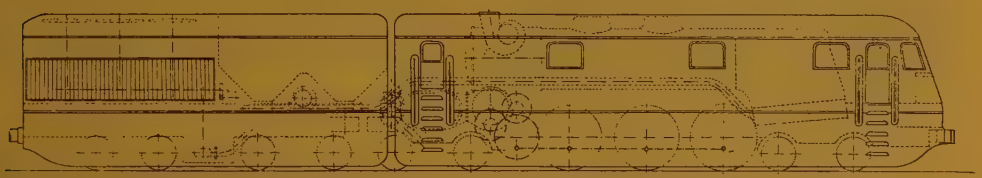


Fig. 3. — Design of a 4-6-4 **turbine locomotive** burning pulverised coal

is shown in figure 3; it is as it were reversed besides being fitted with a casing designed to reduce the air resistance.

At the present time we are considering whether four pairs of coupled wheels would not be preferable, as giving greater adhesion for acceleration and thereby a high tractive effort which can be maintained up to high speed.

The other alternative, the high-pressure locomotive, was even more attractive, as the exhaust was retainted and there is no need to go to the complication involved in condensing. The blast, is, in fact, a really perfect draught producing device, as it automatically proportions the steam production to the consumption. The result was not a real success. In Germany, owing to the low pressure steam playing too great a part in the total work, the double-pressure (60/14 kgr./cm^2 = 853/199.1 lb. per sq. inch) Schmidt-Henschel locomotive, examples of which were also built in England and France, has not shown sufficient advantages to make good the increased capital cost, apart from va-

rious defects that developed, although without serious consequences. It has at least done a certain amount of work in service, unlike the high-pressure (120 kgr. = 1 706 lb. per sq. inch) Löffler-Schwartzkopff, which has not even this consolation to its credit.

There is undoubtedly something tragic in an engineer's work, on which so much shrewd theoretical and constructive thought has been devoted, being removed from service after some trial runs only. Not only did it not show the expected savings, but it did not even show a lower proportion thereof, say 30 %, which might have been acceptable to counterbalance its great complication and bulk. This locomotive, which was much discussed when brought out, is

Fig. 4. — 120-kgr. (1 706 lb. per sq. inch) pressure experimental locomotive, of the Löffler-Schwartzkopff design.

shown in figure 4; it may be said to represent a bold proposition.

These technical events taught us to beware of carrying heat efficiency too far at the expense of simplicity, with its low capital charges and repair costs. This did not mean, however that there was no chance for attempts to still improve the thermal efficiency. All that was needed was to look for the solution in a pressure and superheat compatible with the usual design of locomotive. This is what we have come to. As the Maffei turbine locomotive, with copper firebox, already had a working pressure of 22 kgr./cm² (313 lb. per sq. inch), it seemed feasible with better quality steel (chrome-molybdenum steel, manganese-copper, and constructional steel) to build a 25-kgr. (355.6 lb. per sq. inch) boiler without much increase in weight, and to use this « medium pressure » — as it was called when thinking of the tests with ultra-high pressures — conjointly with a superheat temperature exceeding 400° C. (752° F.) in a compound engine giving particularly economical results.

The three following figures illustrate experimental engines of this kind. Fi-

Fig. 5. — Standard 4-6-2 express locomotive, class 04.

gure 5 represents the class 04 four-cylinder express locomotive built by Krupp. This engine is well-balanced and runs exceptionally well; it was designed originally for a speed of 130 km. (80.8 miles) an hour, but is undoubtedly capable of doing 145 km. (90.1 miles). The class 44 four-cylinder compound goods engine built by Henschel (fig. 6) showed a rather greater economy thanks to its better designed valve motion. The steam consumption of the P 8 locomotive was round about 7.35 kgr. (16.2 lb.) per I.H.P./hour. It fell to 6.4 kgr. (14.11 lb.) with the standard locomotives. The medium-pressure locomotives, with their greater pressure and temperature drops, used much less than 6 kgr. (13.23 lb.),

Fig. 6. — Standard 2-10-0 goods locomotive, class 44.

the express locomotive only using 5.5 kgr. (12.13 lb.) and the goods 5 kgr. (11.03 lb.). The small class 24 medium-pressure 2-6-0 passenger locomotive (2-cylinder compound) also showed the same low figure, which can therefore be considered as typical for 25-kgr. (355 lb.) pressure with very high superheat (fig. 7). In the same way a rebuilt S 10_2

Fig. 7. — Standard 2-6-0, class 24, passenger locomotive.

express locomotive, with a new boiler at 25 kgr. (355.6 lb.) pressure — conversion of inside simple expansion cylinder into the high pressure cylinder of the three-cylinder compound — has shown, by its low consumption on trial runs not yet finished as regards the technique of steam production, a really astonishing superiority in power on the original type which, it must be said, was not too good. These recent consumption figures are reflected, when compared with older locomotives of the same type, in steam savings of 25 to 30 %. The absolute coal consumptions are already less than those of our rebuilt high-pressure locomotive and are almost on the same level as those given by the turbine locomotive in its present form, under its best working conditions.

We have, it is true, experienced some trouble at the joints with the present boiler materials but hope to overcome them by improved shop methods. In spite of this, the consumption figures are so exceptionally good that they encourage and even force us to continue the close, and let us hope profitable, collaboration between the boiler maker, the builder, and the metallurgist. Locomotives with a lower pressure might be used to see which factor — pressure or superheat — was the more important. The results of tests at present available already show that the superheat is. If, therefore, we limit the pressure to 20 kgr. (284.5 lb.) like the French, on their most recent express locomotives, whose consumption is, from the French reports, about 5 kgr. (11.0 lb.) per I.H.P./hour, the use of special steels would perhaps be unnecessary. According to an article in the February 1934 *Revue Générale des chemins de fer*, page 152, out of 7 recent French designs of express engines only 5 had 20 kgr. (284.5 lb.) pressure. This pressure, moreover, unlike the 25-kgr. (355.6 lb.) pressure, can be expanded in a simple cylinder so that we can use simple expansion with its greater elasticity and its lower mean cylinder temperature, which assists the lubrication. The Americans are now using pressures of 17 to 18 kgr. (241.8 to 256 lb.). We can therefore count on steam consumptions of the order of 5.50 to 5 kgr. (12.13

to 11.03 lb.) per I.H.P./hour in the near future.

If this consumption figure be converted into the heat used per ton-kilometre hauled, we get a figure of energy used comparable with that of electric traction supplied by up-to-date power houses at the actual point of use.

If some years ago, the consumption of energy when thus produced by rather old railway generating stations, or by our standard locomotives was exactly the same, we now have a 15 % reduction to put against the more efficient generating stations. Without arguing over an odd percent — it must be remembered that the comparison between the two methods is not solely one of energy consumption — we can say that the opinion still expressed, that from a power consumption point of view, steam and electric traction are on two different planes, is erroneous.

We now have to consider diesel traction. Its advocates can put forward their engine as the best from the point of view of heat efficiency. The diesel engine, however, has the great drawback for railway purposes, of lack of flexibility, as compared with the steam and electric locomotives. It only develops its maximum power at high engine speeds and involves, therefore, special power transmissions for lower speeds. In many cases mechanical (gearing) or hydraulic (oil under pressure) gear can only be built with relatively few steps. A diesel locomotive, therefore, fitted with a transmission of this kind, moreover costly, and not very efficient in the case of the hydraulic transmission, has only 3 or 4 well defined speeds at which to develop its full power. This is not enough especially for main-line locomotives and this leaves only two transmissions, the electric or the compressed-air, which give the needed flexibility of power to suit the tractive effort and speed required. In both cases — except, in the case of the compressed-air transmission, the Deutz experimental diesel locomotive and a modified M.A.N. design not yet built — the full power of the engine can be made available in two ways : diesel engine, electric generator, and electric motor; or diesel engine, compressor, and compressed-air engine. Under these conditions, the diesel locomotive is costly and heavy. A more economical solution on which much enthusiastic work is being done may be the continuously variable hydraulic gear divided into two partial drives (variant of Föttinger's converter). In any case, the diesel locomotives so far have been heavier than steam locomotives of equal power, and as the weight consists mostly of valuable materials the cost per unit of weight is very high. From the point of view of energy solely, the large diesel locomotives have shown that at moderate speeds, i.e. without any great air resistance, the total proportion of the power used at the drawbar, in terms of the fuel used, is 28 % with the diesel-electric, and 23 % with the diesel-pneumatic, whereas our standard goods engine (class 43) gives a figure of 10 %. This superiority of two to two and a half to one over the 14-kgr. (199.1 lb.) pressure locomotive — a superiority which does not exist in the case of the 20-kgr. (284.5 lb.) pressure locomotive — is not reflected by a 33 to 40 % saving on the cost of fuel. As fuel oil is much dearer than coal, from a financial point of view the fuel costs are more or less equal. When the capital charges and maintenance costs of the more complicated engine are taken into account, the diesel service is certainly the dearer.

The results of the new experimental Deutz locomotive, with the partially direct transmission to the wheels, are not yet available. Then, too, as Dr. Lorenz, of Fried. Krupp's, pointed out before the « Brennkraftechnische Gesellschaft » some months ago, the heavy oils imported from abroad are the only ones suitable for burning in diesel engine

cylinders. The purchase of these oils involves the export of capital and if the diesel engines were used on a very large scale — and this remark also applies to railcars — thousands of coal miners would be unemployed. For these reasons, which affect the national financial position, and the fact that the advantages of the diesel are obtained at great cost, we will be led to consider the very simple steam locomotive as the best power vehicle.

What is the position of the steam locomotive as regards maximum power? The electrical engineers usually claim that the superiority of the electric locomotive lies in its greater available power, thanks to the distribution line and the power station as compared with the power the steam locomotive can develop by itself. This is correct as regards the hand-fired locomotive, the maximum power of which, being limited by the physical strength of the fireman, corresponds or is slightly higher than the *continuous* maximum output of a standard locomotive, and reaches, under variable loads, peaks of 2 700 I.H.P. The future locomotives being still more efficient will raise the maximum power to not less than 3 000 I.H.P. Besides, it is not impossible to replace hand-firing by mechanical firing without having to innovate, as *with pulverised coal a* thoroughly well thought-out mechanical firing system is at hand, although so far it has been used mainly for heat economy. An auxiliary oil burner has also been tried; the large American locomotives are generally fitted with mechanical stokers. In the U.S.A. indicated horse-powers of 4 000 to 5 000 have been attained in trials, and Dr. METZELTIN some years ago, in an article in the *Zeitschrift des Vereines Deutscher Ingenieure,* gave 8 000 I.H.P. as the maximum for a steam locomotive.

The articulated multiple coupled locomotives of the Garratt and other (Franco) types could undoubtedly be designed for very high powers. Nonetheless, it would be cheaper and, with the present draw and buffer gear, safer to climb short gradients with a local banking engine than to work very large locomotives over the whole line and consequently work them inefficiently over most of it. I do not know whether the French tests in which 3 000 I.H.P. and even 3 000 E.H.P. were obtained with engines of the same dimensions as our own, by forcing the steam production to 80 kgr. per m^2 (16.4 lb. per sq. foot) of heating surface could be repeated in service without increased boiler repairs. The welding of boilers, now under test, may perhaps enable us to get more from the heating surface. Furthermore, the present tendency is rather to improve the railway service by increasing train frequency so that exceptionally high powers which could only be used over *rising gradients* would not be necessary. In Germany, the really heavy gradients are not very long, so that the working conditions do not become steady and very good speeds can be reached by overloading the locomotives for a short time. Besides, I am not enough of a steam fanatic as to recommend, for example, *Garratt* locomotives for lines such as the St. Gothard. In the mountains, with many tunnels and ample water power, electric operation ought to be used. When *high power* is thought of in the form of *high speeds,* we have naturally in mind express and through trains, and level lines, whereon, under constant working conditions, powers such as mentioned above are rarely fully utilised, and whereon, with a powerful locomotive the few periods of acceleration have little influence on the total running time. One of my electrical friends objected, in answer to this statement, that on a long run speed restrictions are inevitable, and that in consequence the number of periods of acceleration is greater than that provided for in the timetables. Nothing is

truer, but it must be pointed out that for the short periods of acceleration there is no necessity to restrict oneself to the usual steam production of 57 kgr. per m² (11.67 lb. per sq. foot) per hour. Recently in many starting tests on the Hamburg line with 03 class locomotives, the steam production was 70 kgr. per m² (14.34 lb. per sq. foot) per hour enabling at least a 20 % better acceleration.

There is no doubt but that by suitable design the maximum power of the locomotive can still be increased so that, ignoring the fact that the power developed to-day by different steam locomotives is usually all that is needed, we may say the locomotive has no natural limit. To prove this statement, I would call attention to the very heavy 2-8-2 three cylinder express locomotive (fig. 8) now being designed by the Reichsbahn to haul 650-ton express trains at 120 km. (75 miles) an hour on the level and at 60 km. (37.3 miles) an hour on 1 in 100 gradients, with a maximum speed of 135 km. (83.9 miles) an hour. With less than 280 m² (3 014 feet) heating surface and 20 kgr. (284.5 lb.) pressure, its maximum power will not be below 3 000 I.H.P. With a higher rate of steaming a peak value of 3 600 I.H.P. will be obtained, so that its superiority for high speeds over, for example, the class 01 engine with 2 200 I.H.P. will be still more marked, owing to its streamlined casing. The fireman will be called on to give his maximum as no mechanical stoker will be fitted.

Without going any further into the high-power field, I will quote, as an example showing how, with steam traction, a heavy powerful locomotive can shorten the journey time, the actual adhesion working on the Höllental line in the Black Forest, with the well designed class 85 engine (fig. 9) in place of the old rack locomotives. After the line had been suitably strengthened, this locomotive with 20-ton axle-loads took over the service this winter with the

Fig. 8. — Design of a 4-8-4 express locomotive.

following result : the through train time from Freiburg to Titisee was reduced from 79 to 46 minutes and that of the best stopping trains from 93 to 61. The three-cylinder engine gives an exceptionally uniform tractive effort and enables the best use to be made of the

Fig. 9. — Standard 2-10-2, class 85, goods tank locomotive.

available adhesion. No locomotive vibration is felt in the carriage which immediately follows it. The line is to be electrified, however, in spite of ten heavy steam locomotives having been put into the working recently.

To show, in addition, that the designers are not neglecting the small steam locomotive, figure 10 illustrates a light 2-4-2 locomotive for 80 km. (49.7 miles) and in some cases 90 km. (56 miles) an hour maximum speed; this locomotive is intended to haul, as a trial, light trains in accelerated branch line services, or feeder services to the main lines. The design is still to be modified on the lines of the old Bavarian types, by fitting the engine with semi-automatic firing and with means of communication with the train, so that it can be driven by one man.

Now that we have considered the heat efficiency of the locomotive, and the way it can adapt itself to a very wide range of power, we have only, to remove a doubt which remains in connection with the steam locomotive, to discuss the question of speeds and to see if the steam locomotive is still quite capable of meeting the present tendency to reduce still further the running times.

In connection with this, we would like to underline the fact that the 03 class of locomotive mentioned above, when hauling light corridor trains on trial runs over the Hamburg line, showed itself capable of running up to 140 km. (87 miles) an hour, although designed to run at 120 km. (75 miles). The capability of the locomotive to do this work was not admitted until a number of engines of this class, which had their axle boxes and rods carefully attended to, had made a considerable number of runs (34) without anything going wrong. The dynamometer car showed that the total evaporative capacity — 57 kgr. per m^2 (11.67 lb. per sq. foot) per hour — was far from being used, and that with trains of 200 to 240 tons the average steam production of the locomotive was less than 20 % below this figure. The maximum speed recorded during the runs in question was 144 km. (89.5 miles) an hour; since then it has reached 150 (93.2 miles). It was also pleasant to find that a locomotive type of which there are a great number in service could be used without alteration in accelerated services. During the tests in question, the said maximum speed was not maintained over long sections; but a few weeks ago we maintained a *continuous speed* of 140 km. (87 miles) an hour with the object of showing more exactly the available power at the draw bar over long sections. The 03 class of locomotive has now given a speed diagram in which the values corresponding to the high speeds have been given by the test itself, and not by more or less accurate extrapolations beyond the 100 or 120 km. (62 or 75 miles) an hour.

Had there been question, not long ago, of designing a locomotive to run at 140 km. (87 miles) an hour, a balanced

Fig. 10. — Preliminary design of 2-4-2, class 71, standard passenger tank locomotive.

Leading dimensions.

Cylinders, bore	310 mm. (12 13/16 in.).
Cylinders, stroke	660 mm. (26 in.).
Diameter of coupled wheels	1.500 m. (4 ft. 11 in.).
Diameter of carrying wheels	0.850 m. (2 ft. 9 1/2 in.).
Rigid wheel base	3.000 m. (9 ft. 10 1/8 in.).
Total wheel base	8.400 m. (27 ft. 6 45/64 in.).
Boiler pressure	20 kgr./cm² (284.5 lb. per sq. in.).
Grate area	1.37 m² (14.75 sq. ft.).

Heating surface :	
Superheater flues	31.8 m² (342.30 sq. ft.).
Fire tubes	30.4 m² (327.22 sq. ft.).
Firebox	5.53 m² (59.52 sq. ft.).
Total	67.73 m² (729.04 sq. ft.).
Superheating surface	27.4 m² (294.93 sq. ft.).
Water capacity	7 m³ (19 250 Br. gall.).
Coal	3 tons.
Weight empty	45.7 t. (45.0 Engl. tons).
Weight in working order	59 t. (58.0 Engl. tons).
Adhesive weight	30 t. (29.5 Engl. tons).
Maximum speed	90 km./h. (56 m.p.h.).

three or four-cylinder engine would always have been put forward, and we should have had some doubts as to whether a simple engine with 2 cylinders, such as the 03, would be suitable for this purpose. Steadier running, still freer from small disturbing movements is undoubtedly obtained with multiple cylinders and properly balanced reciprocating parts, although we have not had any reason to complain of the 03 type locomotive, when the bearings are well maintained. The 04 type four-cylinder locomotive, with 25-kgr. (355.6 lb.) boiler pressure, shown in figure 5, was originally designed for a speed of 130 km. (80.8 miles) an hour; it runs very steadily, even at high speeds. Then too, in view of the high pressure, the decision to use the compound engine with four cylinders was not the result of any special investigation, but was adopted as being the obvious solution. With the old Baden express compound 4-cylinder engine of the 4-6-2 type (Class C IV H) hauling a light corridor train, we have reached 154 km. (95.7 miles) an hour.

The investigation into high speeds raised, before the trial runs we have just been dealing with, a new problem, that is the reduction of air resistance. Considered in itself, this could be overcome with the present design by increasing the horse power as necessary. But, the moment we consider speeds of 150 to 160 km. (93.2 to 100 miles) an hour — and this is the programme of the *fast locomotives* actually ordered, and designed separately — the first designs, especially that of Borsig, already proposed to use a more or less streamlined shape. We have just seen what pains coal economy has meant from the *thermal side.* Should we therefore abandon any attempt to achieve, by using streamlining, *a power saving* of 10 to 20 %, and more in cross winds? The Borsig preliminary trials made in 1933 were followed, therefore, by our own in the Göttingen wind flume, wherein larger-scale models could be used and consequently greater exactitude obtained in the measurements. The following figures give some idea of these tests. Figure 11 shows as a catoptrical arrange-

Fig. 11. — Double model of the 4-6-4 high-speed locomotive in the wind flume.

ment, a double model of an express locomotive suspended in front of the large opening of the wind flume. The thin steel wires used for making the measurements are clearly visible; they transmit the wind forces acting on the model to the most accurate of the measuring instruments, the balance. For this purpose, after passing over a pulley, they are coupled to the small arms of the balance. The catoptrical method is used to avoid the error due to the air having the same speed relatively to the locomotive and to the track, whereas, in reality, the locomotive moves over the latter. Furthermore the plank which represents the permanent way would brake the wind. The mobility of the suspension gear (fig. 12) about a shaft enables us to get an oblique direction of the wind, that is to say to imitate a cross wind. Each model was tested at

Fig. 12. — Revolving suspension gear for wind flume trials.

three wind speeds, up to 50 m. (164 feet) per second, a speed corresponding to that of the most violent gale. Figure 13

Fig. 13. — Model of the initial form of a 4-6-4 high-speed locomotive.

shows the initial form of the express locomotive, a three cylinder 4-6-4 with cranks at 120° to one another, so that the reciprocating parts are balanced. The joiner's work was so well done that even an expert would have had to examine it very closely to realise that it was

Fig. 14. — Model of a high speed 4-6-4 locomotive with spherical smoke box door and streamlined cab.

not a real locomotive but only a model. Figure 14 shows that attention has been given to the smallest details, such as the hemispherical smokebox door, and the steamlined cab. Figure 15 shows the

Fig. 15. — Model of a 4-6-4 high-speed locomotive completely enclosed.

final form and almost completely cased in shape of the ordinary tender locomotive with the chimney at the leading end. As an extreme form we have also tested (fig. 16) a completely cased in 4-6-4

Fig. 16. — Model of a 6-6-4 high speed tank locomotive.

tank engine which appears to run backwards, the power of which, it is true would be slightly less. The principle of running backwards, even with a tender, but with mechanical firing, has been shown to be practical by the still more powerful turbine locomotive. The form of the first mentioned locomotive

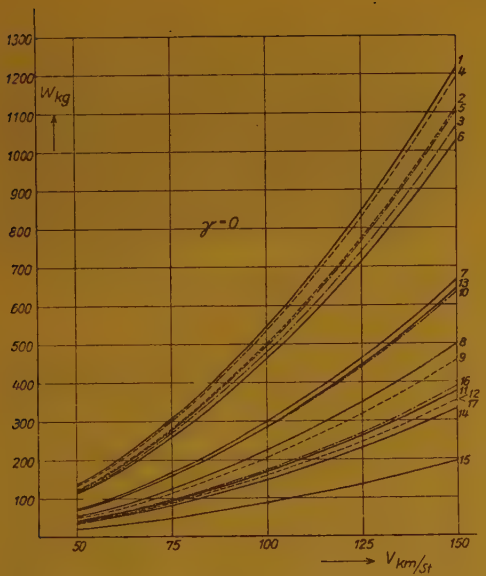


Fig. 17. — Air resistance of 4-6-4 and 6-6-4 high-speed locomotives, with different designs of casing.

is good enough for hauling a train of six metal corridor coaches of the most recent type at 160 km. (100 miles) an hour on the level. Diagram figure 17 shows the results of trials, converted into the resistance in kilogrammes of the actual locomotive in terms of the speed. Without discussing them here in detail, I would like to draw attention to the group of curves at the top of the diagram, which bring out the slight advantage given by well rounded smoke-box door, etc. The scattered group of curves relate to a more or less completely streamlined locomotive with the motion hidden behind an apron brought very low down, and a tender designed to allow the air to run past it without eddies. The lower curves relate to a completely cased-in tank locomotive. At 150 km. (93.2 miles) an hour and in a dead calm, the lower part of this group of curves shows a saving of some 300 H.P.; this saving is even as much as 570 for the reversed tank engine, of rather less power, it is true.

How far can we cover in the locomotive in view of certain factors : insufficient ventilation of the axle boxes, possible eddy currents under the footplate? This is a question we are investigating separately.

A 03 locomotive with ellipsoidal smoke box door, tapered-off cab, and an apron brought very low down has just begun its trial runs. Figure 18 gives

Fig. 18. — 03 class locomotive with the driving gear cased in.

Fig. 19. — 03 class locomotive with the driving gear cased in.

Fig. 20. — 03 class locomotive with the driving gear cased in.

a general view of the engine, figure 19 a front end view, and figure 20 shows how accessible the motion has been made by means of shutters. Figure 21 shows the real type of express locomotive of the 4-6-4 type, with the leading end like an express rail motor car covered in very completely to the back end of the tender. The driving wheels are 2.30 m. (7 ft. 6 1/2 in.) in diameter, suitable for high speeds.

Figures 22 and 23 also show the casing, these figures reproducing the design of a locomotive which appears to run backwards, using pulverised coal, and with a tender, and a tank engine with a closed-in high-speed steam engine driving through a jack shaft. As yet no decision has been taken as regards

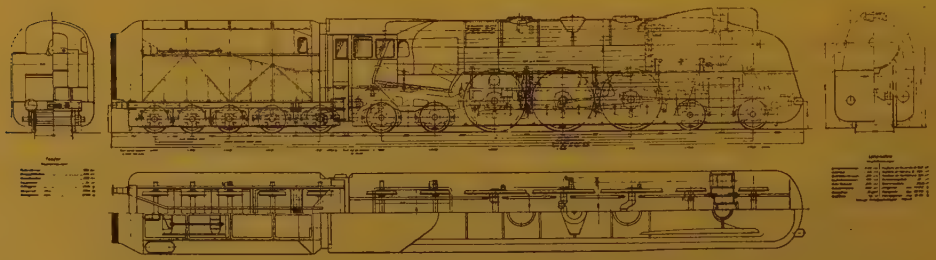


Fig. 21. — Design of a 4-6-4^{h3} express locomotive for 150/170 km. (93.2/105.6 miles) an hour, to haul 535 t. (526.5 Engl. tons).

the construction of these engines; they show, however, that great activity is being displayed in the high-speed steam locomotive field.

There is no doubt that when the casing in is carried too far, the æsthetic appearence of the locomotive is spoilt, and this is so especially with the steam

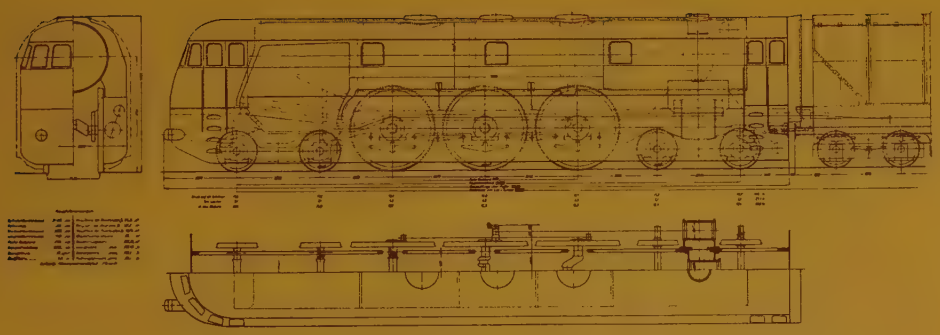


Fig. 22. — Design of a 4-6-4^{h3} express locomotive burning pulverised coal.

locomotive, one of the most beautiful of machines as regards shape. But for specifically fast locomotives the sacrifice of so many H.P. for appearance's sake would be unjustifiable. The technical æsthete must console himself by reflecting that the air resistance increases with the square of the speed so that only at continuous high speeds — over 120 km. (75 miles) an hour — is the unsightly casing necessary. The tests of the locomotive in the air flume show that we are using the most up-to-date methods of measurement, such as those used in aircraft and railcar practice.

The streamlined form is also to be seen in the last two figures, which represent the Henschel design for a steam train (fig. 24). I speak of this design here because the power vehicle is a 4-4-2 standard tank engine, mostly encased. It must be remembered that, 25 years ago, the 4-4-2 locomotive was the type most favoured for express trains, and was only abandoned because it was not powerful enough at starting. With two trailer vehicles only, as in this case, i.e. with the capacity of a large double railcar — 128 seats — 4 driving wheels are again sufficient. The whole train looks rather like a smooth wedge without projections, designed to pierce the air. A conservative calculation shows lower costs per seat-kilometre than that of the « Flying Hamburger ». When figure 25 is examined, it is seen that the streamlined casing hides a real

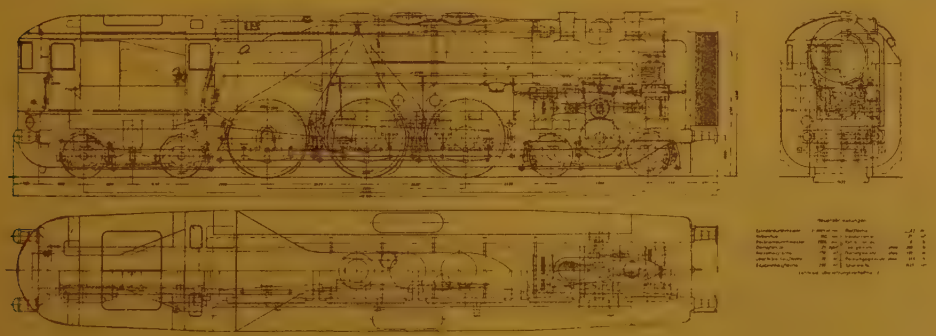


Fig. 23. — Design of a 4-6-4^{h4v} express tank engine for 150/170 km./h. (93.2/105.6 m.p.h.) speeds.

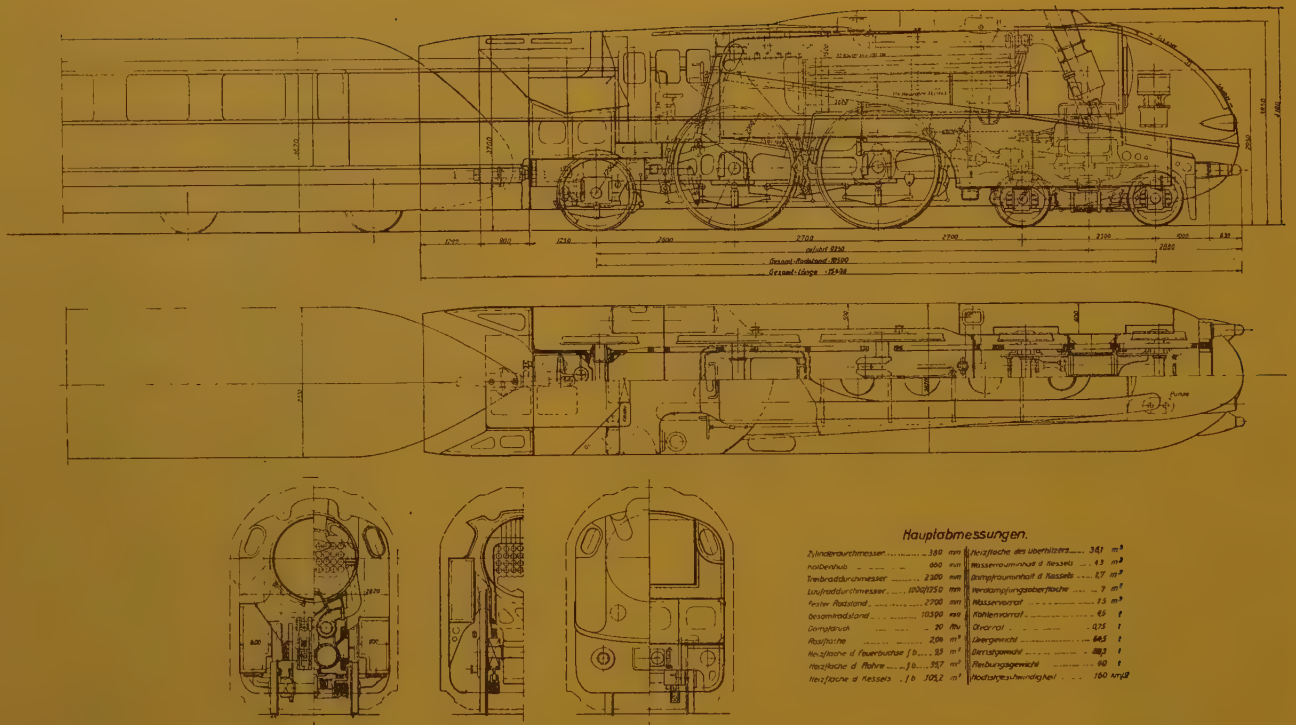


Fig. 24. — Preliminary design of a 4-4-2 express tank locomotive.

Leading dimensions:

Cylinders, bore	380 mm. *(14 15/16 in.).*
— stroke	660 mm. *(26 in.).*
Diameter of coupled wheels	2.300 m. *(7 ft. 6 9/16 in.)*
— carrying wheels	1.000/1.250 m. *(3 ft. 3 3/8 in./4 ft. 1 3/16 in.).*
Rigid wheel base	2.700 m. *(8 ft. 10 5/16 in.).*
Total wheel base	10.500 m. *(34 ft. 5 3/8 in.).*
Boiler pressure	20 kgr./cm² *(284.5 lb. per sq. inch).*
Grate area	2.04 m² *(21.96 sq. ft.).*
Heating surface:	
Tubes	9.50 m² *(10.22 sq. ft.).*
Firebox	95.70 m² *(103.01 sq. ft.).*
Total	105.20 m² *(113.23 sq. ft.).*
Superheating surface	36.10 m² *(388.58 sq. ft.).*
Boiler capacity: water	4.5 m³ *(158.9 cu. ft.).*
Boiler capacity: steam	1.7 m³ *(60 cu. ft.).*
Evaporating surface	7.0 m² *(75.35 sq. ft.).*
Water carried	15 m³ *(4250 Br. gall.).*
Coal —	4.5 tons.
Oil —	3/4 ton.
Weight, empty	64.5 t. *(63.5 Engl. tons).*
— in working order	89.3 t. *(87.9 Engl. tons).*
— adhesive	40 t. *(39.4 Engl. tons).*
Maximum speed	160 km./h. *(100 m. p. h.).*

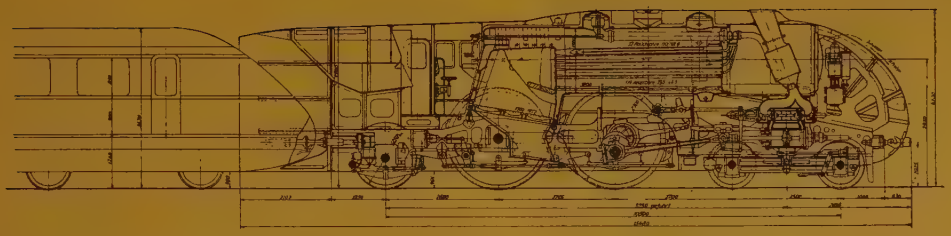


Fig. 25. — Preliminary design of a 4-4-2 express tank locomotive.

locomotive having a pressure of 20 kgr. (284.5 lb.), and the high superheat makes it a modern engine from the economic point of view. The programme provides for a normal speed of 150 km. (93.2 miles) an hour, with a maximum of 160 (100 miles) on level line. The design will not, however, be carried out in this way. In view of the present tendency in Germany to use groups of railcars with a very large number of seats, a decision has been come to in favour of a larger train. Consequently, while preserving the essential parts, this steam train is being transformed into a train consisting of four light carriages with a 4-6-4 locomotive (fig. 26).

Before ending, there is one more remark to be made. In abnormal times, steam traction being self-contained is the least vulnerable. Naturally, a steam locomotive can be put out of action like any other motor vehicle. But it is not possible to *immobilise* at one blow *whole groups of locomotives* as in the case of electric traction by interfering with the working of the generating station or with the nerve centre of a group of transmission lines. Unlike the diesel locomotive and railcar, the steam locomotive does not require imported oil from abroad, but burns the coal of the country.

Thus, the steam locomotive also holds its own in the vital question of speed. *It is old, but not out-of-date.* Whatever may be the future phases of development, and whatever innovations may be introduced, the tubular boiler with its firebox and the blast acting on the fire, and the steam engine with its reverse gear, have demonstrated themselves as a most fertile principle and as the basis for fresh progress, difficult enough to make, it is true, in recent times. The locomotive is so far from being a machine of a passing fashion, that it can almost be compared to a tenacious race always evolving in an ascending direction. And when the history of the technique of our epoch is written, witness will be rendered to the steam locomotive that it has not ceased to progress and that it has not remained at the head of the trains solely because — even as Rome was not built in a day — new rolling stock cannot be put on the rails day by day. May the old and ever young steam locomotive continue to contribute under the new political regime to make the railway for Germany the instrument of wellbeing it has shown itself to be for many years.

* * *

Professor Dr.-Ing. F. Neesen, Dantzig. — When examining the proposed high-speed locomotive mentioned by the author of the paper, it will be noticed that the weight in running order is extremely high. Out of nine pairs of wheels, including those of the tender, there are only three driving pairs, which gives a very unfavourable ratio of the adhesive weight to the total weight, so

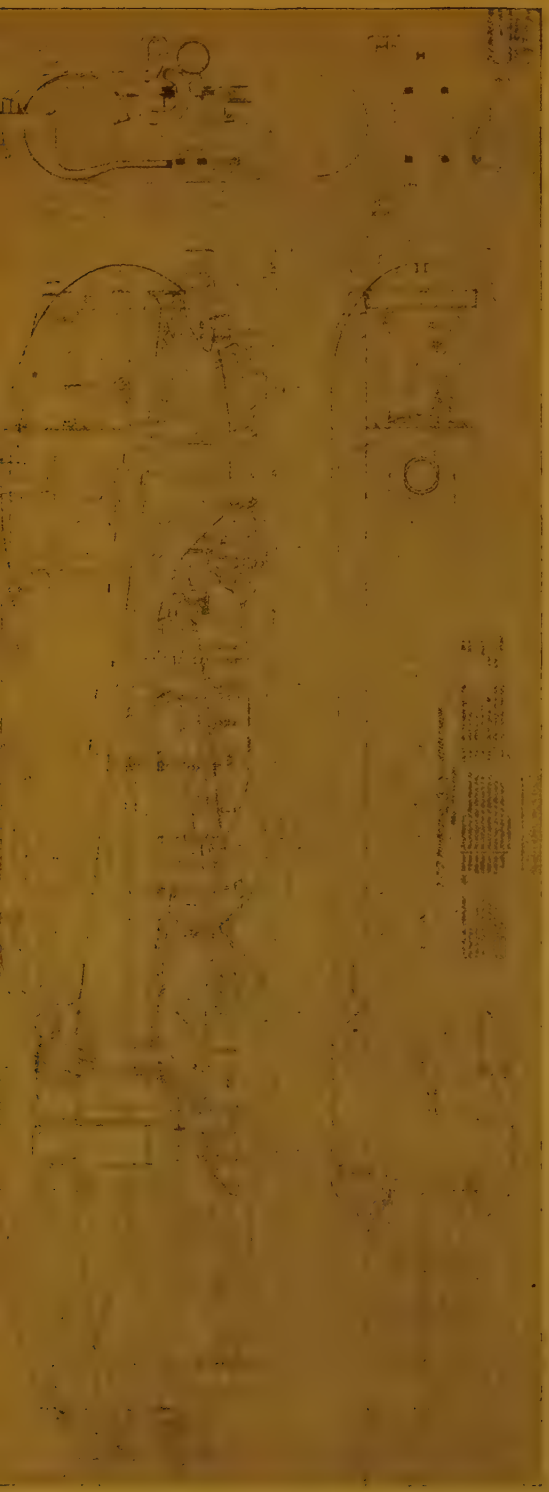


Fig. 26. — Design of a 4-6-4 express tank locomotive for 160 km. (100 miles) an hour.

that the engine hauls a very large dead weight which has the effect of increasing very appreciably the resistances, especially those during acceleration and when climbing up gradients. The high proportion of the dead weight relatively to the tractive effort is one aspect in which the steam locomotive is inferior to the electric locomotive. With our present knowledge it is possible to reduce the weight, and the design should be developed in this direction, as the reduction of weight gives a large number of other advantages.

The principal elements of an improvement of this kind would be the following :

1. Reduction of the weight of the boiler by reducing the volume of water, increasing the efficiency of the heating surface, and increasing the efficiency of the boiler, which would be possible, for example, with a Velox boiler.

2. The reduction of the volume of water would make it necessary to regulate the fire more precisely. This result can only be obtained by automatic stoking. With a smaller volume of water less time would be taken to raise the pressure. Automatic firing makes it possible to move without difficulty the driver's cab to the front end of the engine and gives the locomotive a good streamlined shape.

3. Reduction of the materials consumed by using condensing. Calculation shows that the condensing system which gives the best results is to use the piston engine and to use an exhaust steam turbine for driving the feed pumps, condensers, the exhausters, electric light and other auxiliaries. In this way the steam engine, so good as regards its intrinsical value, would remain; the steam would be used under good conditions, the boiler would be husbanded, the weight of the fuel would be reduced, and the radius of action would be increased. It would be possible, moreover, to use standard designs of engine.

4. Another improvement in the express locomotive would be to use the steam engine with transmission gear in order to eliminate first of all the unfavourable effects of the reciprocating masses.

Dr.-Ing. Litz, Berlin. — The proposals of Professor Neesen relate to an evolution which undoubtedly will only occur later on.

For the time being, we should deal with proposals of more present-day interest, and from this point of view all steam locomotive builders should sincerely thank Professor Nordmann for having again, with such brilliant argument, broken a lance in favour of the steam locomotive and its future improvement.

The steam locomotive has proved its worth in all periods, but what it lacks to-day is the enthusiasm of those who build it and of the public. Nobody is astonished when, without any special preparation, a steam locomotive for express trains, which has been in service for ten years, covers the Berlin-Hamburg run in a time and at a speed which are almost the same as those of the « Flying Hamburger ». Nobody displays any enthusiasm for the idea that a still better result could be obtained, when a steam locomotive has been built for high speeds, with streamlining, good visibility, etc. Now, the proof that efforts have been made in this direction for some time is supplied by the fact that the Reichsbahn has recently ordered from Borsig a steam locomotive intended to attain a speed of 170 km. (105.6 miles) an hour, which will probably be put into service before the end of 1934.

The locomotive stock of the Reichsbahn consists of 20 000 steam locomotives, 1 300 railcars of all descriptions, and 500 electric locomotives. In face of these figures we are obliged to conclude that, if only for purely economic reasons, more attention should be given to improving the steam locomotive than has been done recently, and for the two special reasons that it uses our coal which exists in limitless quantities, and that it enables us to use for other purposes of still greater importance the oil used on railcars.

To Professor Nordmann's question : « Is the steam locomotive already out-of-date? » no better negative answer can be given than by basing the reply on the technical arguments he has so brilliantly put before us. All that is required is the same enthusiasm for the steam locomotive as has been so strongly displayed for railcars. It is true that in this case it is not a question of raising enthusiasm for something quite new, but for an engine which has already shown its merit, and which is now presented in a new form.

Professor Dr.-Ing. Nordmann, Berlin. — In principle we can but agree with the theory put forward by Professor Neesen relating to the smallest possible weight. But if this problem is to be solved by complicated and unknown methods of construction, such as the Velox boiler, it is not at the present time directly applicable to *ordinary service*. Such a design can look very well on paper; but as we are mainly considering the improvement of fast train service, the railway engineer must first of all develop locomotives which are really able to run immediately, seeing that they are built of parts all of which are well tried. This guarantee cannot be given by any untried design. In any case, the result of the trials of our ultra-high pressure and turbine locomotives bid us to be somewhat cautions.

The objection made to carrying wheels is hardly justified in the case of high-speed locomotives. Owing to the high speed, high powers only require moderate tractive efforts so that an excessive adhesive weight is not needed. In this case, the carrying wheels must be considered rather as the supports of a powerful motor vehicle and consequently must be rather heavy. For this purpose

— ignoring the tender — the steam locomotive does not in principle differ from electric locomotives; the heavy goods electric locomotives, such as the 1-Co + Co-1, have carrying axles for this purpose; the same thing applies to the double locomotives of the St. Gothard.

This does not mean that Professor Neesen's suggestions should not be followed up; I would see with pleasure his locomotive with Velox boiler attached to a dynamometer car. But it would only be the test of a system, while we are endeavouring to adapt a proved type to higher powers and speeds.

RECENT DEVELOPMENTS.
IN RAILWAY PRACTICE.

[625. 242 (.42)]

20-ton welded coal wagons for the London and North Eastern Railway Company.

The London & North Eastern Railway Company are putting into traffic 100 locomotive coal wagons which have been built by The Metropolitan-Cammell Carriage & Wagon Company to the requirements of Mr. H. N. Gresly, Chief Mechanical Engineer, L.N.E.R.

The underframes are to the standard Railway Clearing House dimensions and the running gear, buffing and draw-gear also conform to the Railway Clearing House standard, indiarubber springs being used. The overall height is somewhat less than that of the standard 20-ton mineral wagon to permit of the wagon passing colliery screens and coaling stages where clearance is restricted. Two pairs of vertically hinged doors are provided on each side.

Fig. 1.

Fig. 2.

In general design the wagons are similar to the standard mineral wagons recently built by The Metropolitan Cammell Carriage & Wagon Company. The underframes are of acid open-hearth steel and the body sides, ends and floors are of copper-bearing steel.

The employment of welding has enabled the tare weight to be considerably reduced, the tare of the welded wagon being 7 tons 19 cwts. 1 qr. compared with 8 tons 17 cwts. of a wagon with wooden body. The capacity has also been increased from 767 to 820 cubic feet.

Further advantages have been obtained in consequence of the welded construction. As the floor plates are welded to the underframe members, the strength of the underframe structure has been considerably increased. The joints between the floor plates are also welded and water is prevented from passing through the floor of the wagon to the underframe members, and causing corrosion.

Suitably spaced drainage holes are provided in the floor clear of the underframe members.

The length over headstocks is 21 ft. 6 in., the inside length 21 ft. 5 5/8 in. The width inside is 7 ft. 11 5/8 in. and the height inside 4 ft. 9 1/2 in.

NEW BOOKS AND PUBLICATIONS.

[621.132.1 (.43)]

MAEY (Hermann), Engineer. — **Die Einheits-Lokomotiven der Deutschen Reichsbahn im Bild** (*Reichsbahn standard locomotives illustrated*), 4th edition. — A pamphlet (8 1/4 × 5 3/4 inches), of 40 pages, profusely illustrated. — 1935, published jointly by Deutsches Lokomotivbild-Archiv, Darmstadt, Techniche Hochschule, and Verkehrswissenschaftliche Lehrmittelgesellschaft m. b. H. bei der Deutschen Reichsbahn, Berlin, W. 9. (Price : 1.80 Reichsmark.)

This small work is the first of a series intended to illustrate the motive power stock of the Reichsbahn. This one, relating to the standard locomotives, is in its fourth edition and has been entirely rearranged. The 31 excellent photographs forming this pamphlet give a very good idea of the standard stock; they show in particular the 01, 02, 03, and 04 types of *Pacific* locomotives for express trains; the 24 class of the 2-6-0 locomotives for ordinary passenger trains; the classes 43 and 44 of 2-10-0 goods locomotives, as well as the different types of passenger tank engines or goods engines for standard or narrow-gauge lines. A short introduction gives the conditions under which standardisation was carried through, and insists especially upon the idea that « standardisation » should not mean « stagnation » and that the Reichsbahn does not cease to introduce all possible technical improvements.

The work is completed by two descriptive tables giving the leading dimensions and features of the locomotives illustrated. These enable the reader to appreciate the data which governed their construction.

A. C.

[656.256.3 (.75)]

ASSOCIATION OF AMERICAN RAILROADS (A. A. R.), SIGNAL SECTION. — **American Railway Signaling Principles and Practices.** — Chapter XV : **Automatic block systems.** — One pamphlet (8 × 6 inches) of 34 + 12 pages, illustrated. Published by the Signal Section of the A. A. R. — 1935, New York, N. Y., 30, Vesey Street. (Price : 25 Cents [15 Cents to members and railroad employees] — Set of 19 Chapters, $ 4.10 to members and railroad employees and $ 6.00 to non-members not employed by railroads. — Binder to accommodate 13 Chapters : $ 1.00.)

The standard code of the American Association of Railroads defines the automatic block as consisting of a series of sections covered by block signals operated electrically, pneumatically, or by other means, controlled by the train or by certain conditions affecting the use of a section. The block signal is placed at the entrance to a section and applies to the trains which run into and use the section.

A brief history is given of the first automatic block signal, that of Hall, which appeared in 1866. After various stages of development, in 1906 colour-light signals were introduced, position signals in 1915, and the combined signals (colour and position) in 1921. Tests with alternating current track circuits for electrified lines commenced in 1902.

The note gives in concise terms a cer-

tain number of definitions which are very useful for making clear the distinction between the different systems of automatic block signalling.

There is first of all the single-line block system, which allows the trains to run in the two directions, and the block on double or multiple-track lines with the tracks signalled for operation in one direction only, but with the possibility in congested areas of allowing trains to run in both directions on one or more tracks.

There is also the system with the signals normally at clear, and that with the signals normally at danger.

Various apparatus used in the automatic block system are described in detail in other chapters : direct-current track circuits in Chapter VII, alternating-current track circuits in Chapter XI, semaphore signals in Chapter XII, and light signals in Chapter XIII.

This Chapter XV gives the principles and circuits applicable to the various cases.

Thus, on multiple-track lines the two-block indication type is generally installed or also the three-block indication. With the former, the signal, a three-aspect signal, shows in its best aspect that there are at least two free sections in advance of it; the second can give four indications. The first system can be used for track which is normally open, with colour lights or semaphore signals, with direct-current track circuits or with alternating-current track circuits. Various designs of this kind are described in the three-block indication system.

On single-track lines there are two sorts of installation : the overlap system and that which combines the permissive and the absolute signals. In the latter, the signals controlling the entry into the sections of line limited by holding sidings are « absolute » signals or « stop » signals, whereas when trains are running in the same direction, the intermediate signals showing the subdivision into sections, and commonly known as permissive signals, generally give the most restricted indication, namely passage after stopping.

E. M.

[651 & 656 237]

RIEDEL (P.), Chief Inspector of the Deutsche Reichsbahn Accountancy Department at Headquarters. — **Neuzeitliche Organisation im Eisenbahnguterverkehr. Abrechnung — Kontrolle — Statistik** (*Up-to-date organisation in railway goods traffic. Accountancy — Control — Statistics*). — A pamphlet (11 5/8 × 8 1/4 inches) of 52 pages with many illustrations. — 1934, Berlin, W. 30. Publisher : Verlag für Organisations-Schriften G. m. b. H., Molzstrasse, 79. (Price : 8.75 Rm.)

The importance of statistics in railway operation and the extension given in recent years to methods and machines based on the use of perforated cards is well known.

A vast field of application is that of goods transport, the accountancy, control, and statistics of which involve very much work. The Reichsbahn system has some 9 000 goods offices which had to deal, in 1932, with 121 000 000 consignment notes representing receipts of some 1 729 000 000 Reichsmark.

The use of perforated cards was tried in 1911, but the machines, at that period, were not sufficiently reliable. In 1925, the railway decided to carry out tests on a large scale in connection with the accountancy of goods traffic. The results were not such as would have led to the system being made general, although the author considers that no

other field was so well suited to this method. At the present time, it is being used in about 2 000 goods offices.

In his work, the author gives particulars of an experiment which has lasted more than six years already. After giving a detailed description of the present method of organising dispatches, he shows how the work is carried out by means of perforated cards and all the advantages that can be obtained therefrom, both in simplifying the accountancy work and in improving the control and making the statistics more useful.

The organisation described by means of documents actually in use is a remarkable example of the application of the perforated card system.

The author also shows the particular importance of the new method in dealing with the accountancy of door to door traffic which the Reichsbahn is now developing, transport by railcars, and the transport over the Reich motor roads (Reichsautobahnen).

E. M.

[656. 235 (.460) & 656. 24 (.460)]

D'OCON CORTES (E), Assistant Chief Officer of the Commercial Department, Madrid-Saragossa & Alicante Railway. — **El Problema de las detasas.** Las reclamaciones por excesos de portes y las juntas de detasas (*The problem of rate reductions. Claims against high rates, and the Rates Committees*). — One pamphlet (9 7/10 in. × 6 1/2 in.) of 84 pages. — 1934, Madrid, Asociación General de Transportes por via ferrea. Calle del Prado, 26.

The Spanish law of the 18th July 1932 introduced important reforms in the procedure to be followed to solve the difficulties arising from claims against charges which the railway users considered excessive or incorrect.

Article 1 of the law states that the actions are debarred after six months.

Article 2 set up in each provincial chief town a Rates Committee which was to examine and dispose of all claims in connection with reductions in charges.

Article 3 fixed the composition of the Committee. This Committee was to consist of a representative of the Railway Companies, one of the Provincial Chamber of Commerce, and a State Controller of operation.

Article 4 provided for an appeal to the Minister of Public Works.

The scheme aroused very strong opposition from those who were interested in claims in connection with the rates. It was discussed at considerable length before the Cortès. The fact that the law has been voted and the decree for its application published has not put an end to the controversy.

The author's object has been to set out the situation which existed before the passing of the law, to analyse the requirements of the law, and to indicate the results obtained after the law had been in force a year, which can be considered as a trial period, and finally to indicate how the law should be altered and strengthened by supplementary legislation.

To the report are appended official documents containing in particular the discussion in the Cortès, the definitive text of the law, the decree of application, and the supplementary instructions for enforcing the law.

E. M.

[313 : 385 (.44) & 385. 113 (.44)]

GODFERNAUX (R.), Engineer, Member of the Committee for Public Works in the Colonies, France, Director of the *Revue Générale des Chemins de fer*. — **Les Grands Réseaux de Chemins de fer français**, année 1934 (*The French Main Line Railways, 1934*). — A pocket book (4 1/2 × 6 3/4 inches) of 40 pages. — 1935, Paris, Dunod, 92, rue Bonaparte.

This booklet gives the usual statistical tables showing the activity of the French main-line railways during the year in question.

The tables of the general operating results show a nett receipt of 84 000 000 against a deficit or 454 000 000 francs in 1933. But when various charges are taken into account the financial situation shows a deficit of 3 500 000 000 francs for the year 1934.

Interesting information upon which the author bases his comments is given in the table showing the profits obtained by the State from the working of the railways. These profits, consisting of various taxes, and the savings effected on postal traffic, army transport, etc., amount in all to 2 600 000 000 francs.

Certain figures are given to show the level of the taxes and the present rates relatively to those of 1914.

In his reflections under the heading : Physiognomy of the year 1934 and first review of 1935, the author sketches the position of the main-line railways. In spite of the tremendous effort made to cut down expenditure, which has saved 1 250 000 000 francs, the deficit exceeds that of 1933. The causes are the crisis, which has become worse, and has affected domestic activities as much as the export trade, and the competition of road motor vehicles which became more intense in 1934. The author gives some very striking figures on this point. He shows also that air competition is far from being negligible.

The remedies now being applied are analysed shortly under two headings : measures due entirely to the initiative of the railways, and the influence of the intervention of the public authorities. Our readers know the principal steps taken, from the articles published in the *Bulletin* on the competition of other forms of transport. The summary given here together with a synoptic table is very illuminating. The author regrets the slowness with which the public authorities intervene, as it delays the results to be obtained therefrom.

After making certain reserves as regards « panaceas », such as electrification and railcars, he shows that even in the present situation the major part, perhaps three quarters, of the deficit is due to the demands of the State, and he hopes that the question of the chronic deficit of the railways will be solved some time.

[625. 1 (.43) & 656. 2 (.43)]

BESSER (F.), Privy Concillor, Ministry of Communications of the German State. — **Kommentar zur Eisenbahnbau und Betriebsordnung vom 17 Juli 1928** (*Commentary on the Rules for the construction and operation of railways*). — 4th edition, revised and enlarged. One volume (8 × 6 inches), of 319 pages. — 1934, Berlin, published by the Verkehrswissenschaftliche Lehrmittelgesellschaft m. b. H. bei der Deutschen Reichsbahn, Potsdamer Platz, 1. (Price : clothbound : 7.15 Reichsmark.)

This work completely reproduces, with commentaries and appendices, the regulations governing the construction and operation of the German State Railways, according to the new edition of the 17th July 1928, as well as the regu-

lations for the construction of public narrow-gauge railways and vehicles, of the 24th February 1934, and the rules in connection with the qualifications required from the staff, of the 30th October 1930.

The table of contents outlines the various subjects dealt with by the author in connection with broad and narrow-gauge railways — *Permanent way construction,* width of the formation, gauge, maximum gradients, platforms, signals, etc... — *Rolling stock,* loading gauge, axle loads, distance between axles, draw and buffing gear, brakes, etc. *Permanent Way Department regulations* relating to the track, and regulations to be observed by the public.

The book contains, in addition, a commentary on the conditions to be fulfilled by the various grades of the operating staff.

Readers will be interested to remember that the German railways as regards construction and operation are based on the working regulations -- Bau- und Betriebsordnung.

For this reason, the book is of great interest to railwaymen of other countries who will find in it ample material for reflection and for comparison with the conditions prevailing on other railways. Finally the author's standing guarantees the correctness with which the official texts of his own railway have been interpreted.

R. D.